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THE DAVIDSON "GYROPTER" FLYING MACHINE.

By Our English Correspondent.

Some few years ago we described in the columns of the Scientific American the experiments that were carried out by Mr. George L. O. Davidson of Banchory, Scotland, with models of a new type of flying machine. The models were of a primitive character, but they sufficed to demonstrate the possibilities of his idea, and subsequently the inventor left England for Montclair, Col., where a full-sized machine was constructed.

The machine is based upon a theory which the inventor evolved some twenty years ago, and the principle may be grasped from the accompanying diagram. The ground is represented by *AAA*. *B* represents a structure capable of exerting an upward thrust, the air being used as the fulcrum. *B* weighs say one pound, and is suspended say one foot above the ground. Under these circumstances *B* has a constant and vertical pull of gravity to the ground of one. If therefore a vertical upward thrust of one is exerted at *B* toward *C*, the forces being equal and counteracting one another, *B* will remain in its position. Should the upward thrust exceed one, then *B* will travel toward *C*, while on the other hand should it be less than one, *B* will fall toward *A*. Should the upward thrust from *A* upon *B* be equal to one though not in an absolutely vertical direction, but say in the direction of *D*, then *B* must travel forward toward *E*, that is, in the direction of half the angle created by the direction of the two equal thrusts, the force which causes it to travel toward *E* being the resultant of the two thrusts. But should the upward thrust toward *D* exceed the unit of one, then *B* will travel toward *F*, that is, in the direction above half the angle. If this thrust toward *D* is increased and greatly exceeds one, *B* will travel toward *H*, which is not only above half the angle, but also above the horizontal, so that *B* falls forward and upward as a result of the two thrusts.

In the apparatus the design of the bird is closely followed, but the flapping of the wings is reproduced in a rotary form by means of novel gyroscopic rotary lifters, revolving horizontally upon vertical shafts, thereby producing an upward thrust, which as the peripheral speed of the lifters is increased greatly exceeds the gravitational pull, while by means of controlling the angle of the gyropters the horizontal speed of the machine is regulated at will.

The apparatus shown in the accompanying illustration has a tip-to-tip measurement of 67 feet, while the length from beak to tail (the two latter not being placed in position) is 60 feet over all. The body of the machine from back to front is 30 feet, while it is 8 feet wide by 13 feet in height.

The body is substantially constructed of 1¼-inch steel tubing and wood thoroughly braced and strutted together. Crossing the roof of the body centrally and at right angles is a substantial wooden and steel reinforced pair of trusses. At the center line of the car they are spaced about 5 feet apart, but at their tapered extremities they converge and form a bed for the bearings of the vertical shaft upon which the gyropters rotate. This shaft is hinged to the main truss bearing in one direction, so as to permit the former to swing through a limited travel in a line parallel with the car, in order to give the necessary inclination to the gyropters.

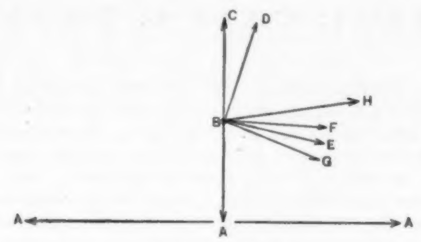
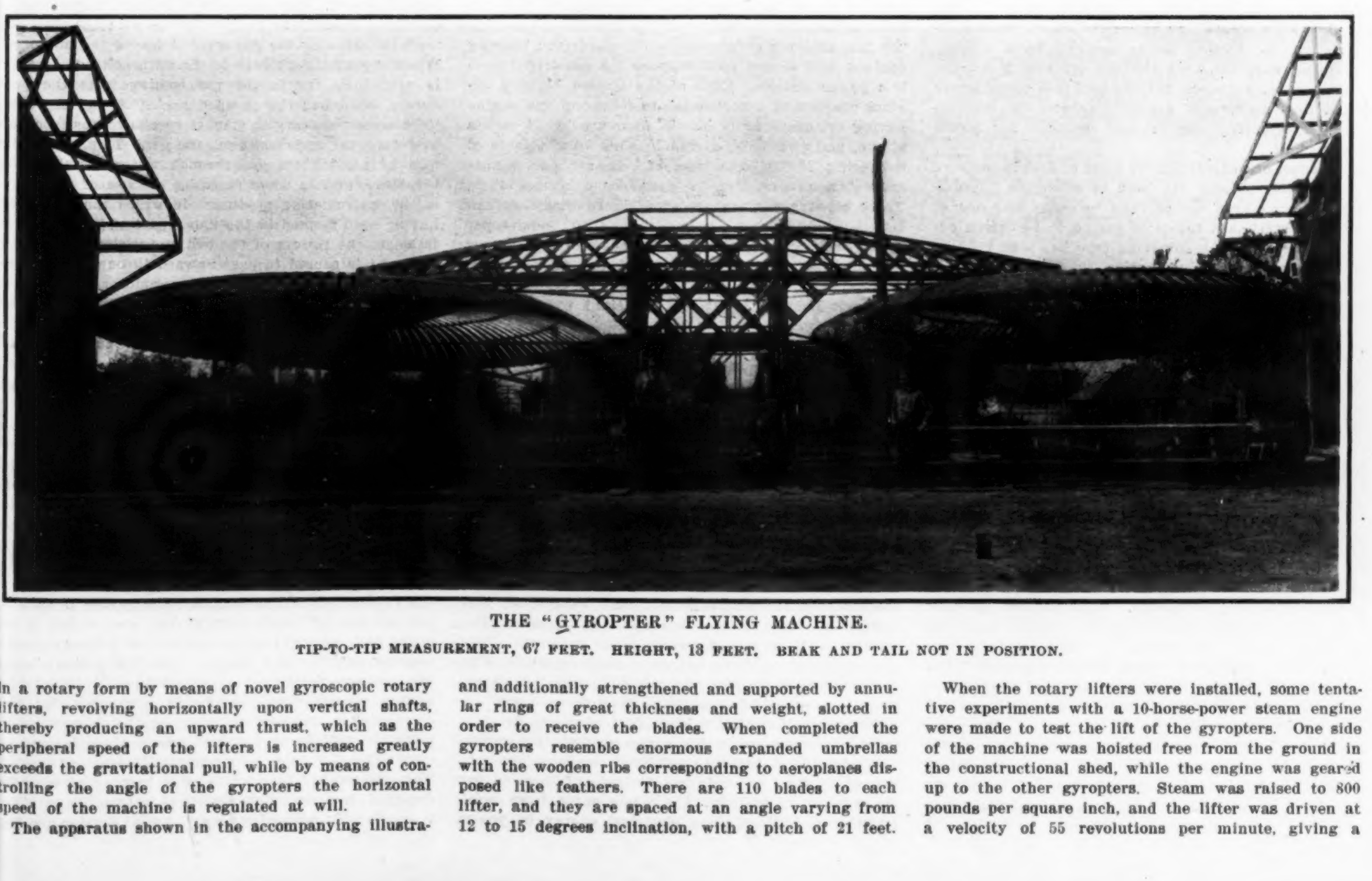


DIAGRAM EXPLAINING THE DAVIDSON THEORY OF FLIGHT.

The gyropters which comprise the most important feature of the machine are of substantial construction. The vertical shaft upon which they revolve is of steel, and the lower bearing is braced to the hub by diagonal spokes or ribs, and is held in a rigid vertical position by numerous steel tube stay rods, firmly anchored to the body of the car. The lifters are built up of a series of blades made of wood, extending from the hub of the lifter to the periphery and additionally strengthened and supported by annular rings of great thickness and weight, slotted in order to receive the blades. When completed the gyropters resemble enormous expanded umbrellas with the wooden ribs corresponding to aeroplanes disposed like feathers. There are 110 blades to each lifter, and they are spaced at an angle varying from 12 to 15 degrees inclination, with a pitch of 21 feet. The lifters are each 27 feet 8 inches in diameter, and they are spaced 40 feet apart from center to center. The blades are each 8 feet in length, and present a total cutting edge of 1,760 feet.

The beak follows the design of that of the bird, having a sharp point to cut through the air, and to turn the air thus forced aside beneath the gyropters. It can be moved to secure right or left deviation. The tail is also of novel design and works automatically. It follows the swallow tail of the bird in shape, and is made in three sections. The central part is hinged to the body, the side sections to the middle section. By this arrangement the side pieces can be deviated either above or below the central section. This tail controls the angle to the horizontal. It can be set to maintain the forward motion at any angle, or can be altered by the manipulation of a hand wheel. The tail also serves to govern partially the lateral equilibrium of the whole machine, but it must be pointed out that the stability of the structure is principally maintained by means of the gyroscopic action of the rotary wing lifters.

The propelling installation consists of two small steam engines, each developing 50 horse-power. In order to have the same lifting power imparted to each lifter, so as to secure a perfect balance of power transmission, the two engines are controlled by a novel automatic governor acting on the throttles. The engines will be bedded near the floor of the body, so that the center of gravity may be kept very low, thus rendering more remote the possibility of the machine overturning. The drive will be transmitted to the rotary lifters by means of helical gearing or preferably belting. The lifters are designed for a speed of 60 to 100 revolutions per minute, and this gives the gyropters a peripheral speed ranging from 5,000 to 9,000 feet per minute. This represents a covering of from 80,000 to 120,000 square feet of air per second, which, even allowing as much as 90 per cent of slip, is sufficient to obtain a lift of over 10,000 pounds per foot per second. The machine's total weight is 6,000 pounds.



THE "GYROPTER" FLYING MACHINE.

TIP-TO-TIP MEASUREMENT, 67 FEET. HEIGHT, 13 FEET. BEAK AND TAIL NOT IN POSITION.

When the rotary lifters were installed, some tentative experiments with a 10-horse-power steam engine were made to test the lift of the gyropters. One side of the machine was hoisted free from the ground in the constructional shed, while the engine was geared up to the other gyropters. Steam was raised to 800 pounds per square inch, and the lifter was driven at a velocity of 55 revolutions per minute, giving a

peripheral speed of over 4,665 feet per minute. Although the lifter was simply acting on confined air within the shed, it enabled the machine to rise vertically; but as the steam pressure owing to the small boiler used could not be kept up, the lifting though of a decisive nature could not be maintained more than a few seconds at a time, the machine rising and falling with the fluctuating steam pressure.

These experiments were brought to an end by the boiler exploding. Though not inflicting serious damage to the lifters, the main body of the machine was entirely wrecked. The damage was not repaired, and the experiments are to be continued in London, where arrangements are being concluded for the construction of a second and more perfect machine, in which angle steel will enter largely in its construction in lieu of wood and steel tubing, the latter having been found unsuitable since it is liable to buckle. The experiments with the small engine, however, served to demonstrate that a machine could be constructed capable of lifting itself bodily from the ground in a vertical direction. The fact that with two 40-horsepower steam engines the inventor can secure an upward thrust in excess of 1.5 tons with each lifter, which is more than sufficient to lift the whole structure from the ground and support it in the air, has been conclusively ascertained.

The control of the inclination of the gyropters is very simply effected. At the lower extremity of the vertical shaft of each lifter is a toothed quadrant, with which the shaft engages. By moving this quadrant in either direction from the floor of the car by hand wheel, the gyropters can be inclined either forward or backward, the angle being very slight, but adequate to alter the direction of the upward thrust, so that the resultant thrust tends to give the machine either a forward or backward motion in a horizontal direction. No preliminary impetus to the machine to overcome its inertia is requisite, and it can start from the ground level, ascent being attained as soon as the speed of the rotary lifters becomes sufficient to give an upward thrust exceeding the downward pull due to gravity.

At Montclair the inventor devised a shed built in two sections and mounted to travel upon a railroad track, each half of which was simply drawn aside, leaving the machine free on the ground. Several suitable sites have been placed at the disposal of the inventor in England, in order to enable him to continue his experiments, while more than one well-known engineering company has volunteered the services of its staff to assist in the mechanical and engineering details. It is anticipated that the building of this second machine will be commenced soon.

ADVANCES IN MECHANICAL ENGINEERING.*

IMPROVEMENTS IN PRIME MOVERS AND CUTTING METALS.

BY PROF. CARL C. THOMAS.

The past year has seen very few innovations in engineering matters, but in spite of the financial depression, considerable progress has been made in almost all of the important branches now occupying the attention of engineers.

In the field of mechanical engineering probably the most striking development has been that of the larger prime movers, notably the steam turbine and the internal combustion engine. The question is frequently asked, "Will not some one form of prime mover drive out of existence the other forms of engine?" Experience does not point, so far, to the probability of any one or two types of prime mover taking the place of or supplanting all the others. The steam turbine has not driven out the reciprocating steam engine; it has taken its place for certain uses, and the reciprocating engine will probably not regain the position it formerly occupied. However, the inherent qualities of the reciprocating engine are such that it is likely to remain superior to the steam turbine for certain special uses. In the same way the gas engine, while it has taken the place of the steam engine in special cases and will probably retain what it has won for a long time to come, is not so well adapted to the driving of alternate current generators in central stations, and for running many classes of machinery as is the steam turbine. The question as to the probability of hydraulic turbines driving out of use all forms of heat engines may be answered in a somewhat different way: If falling water were available within practicable distance of all places where power is desired, it is probable that it would, in connection with electric apparatus, supplant heat engines for nearly all stationary power purposes, but the fact that water power is not thus universally available assures the continuance of extensive use of heat engines for power development.

The effect of competition for place of first importance among prime movers has been to stimulate improvement of each type rather than to cause any one of the well established forms of engine to be driven out of the market. Each surviving type has been brought to a higher state of perfection than that which it would have reached if it had had the field to itself. It is a question not alone of relative fuel economy, but of general adaptation to specific purposes, reliability of operation, simplicity of parts, and ease of repair. It is natural that the reciprocating steam engine should lead in many of the above points because of the length of time it has been in use; but the steam turbine and the internal-combustion engine are forcing themselves into important places because of their special merits and are now operating machinery in fields where the reciprocating engine formerly held full sway.

The large gas engine of from 500 to 2,000 or more brake horse-power, using as fuel what was formerly the waste gas from blast furnaces, has been applied to operating the rolling mills of steel plants and to the generation of electric energy. Such engines are now coming to be regarded as the rule rather than the exception in steel works, and are displacing the steam driven blowing engines which formerly delivered the hot blast to furnaces for the reduction of iron ores.

Electricity is occupying a more and more important position in steel mills and the governing of gas engines has been improved so materially that central stations in connection with steel mills are being equipped with electric generators, operated by gas engines as prime movers. The difficulty of varying the speed of gas engines within wide limits and of reversing such engines has so far prevented their adoption for direct connection to rolling mills, but gas engines may be used to operate electrical generators, and ingenious systems of electric driving of such mills have come into use and are apparently giving satisfaction in the operation of rolling mills for the production of rails and structural steel.

Large gas engines are also being used for the direct driving of high-pressure pumps and in cases where such pumps are continuously operated, the service seems entirely satisfactory. If there were to be frequent stopping and starting of the pumps, the problem would be much more difficult and perhaps the gas engine would not be capable of handling the work. In this case as in that of the rolling mills, electrical means are resorted to, and motors have been produced which will run with satisfactory regularity at any speed required from zero to the maximum for which the motors are designed.

In the new plant of the Indiana Steel Company at Gary, Indiana, the largest works of their kind in the world, there are to be sixteen blast furnaces producing about 45,000,000 cubic feet of gas per twenty-four hours, equivalent, when used in gas engines, to about 300,000 brake horse-power. Approximately 30 per cent of this gas is taken for heating the stoves supplying the hot blast to the furnaces. About 7½ per cent is used in steam boiler furnaces, 5 per cent is used for small auxiliaries or is lost in the process of cleaning the gas, 12½ per cent operates the gas-driven blowing engines, and 45 per cent supplies the gas-driven electric power station. Each of the sixteen blowing engines consists of a horizontal, twin-tandem gas engine having cylinders 42 inches in diameter by 54 inches stroke, and two direct-driven blowing tubs capable of delivering 30,000 cubic feet of free air per minute against a pressure of 18 pounds per square inch. These blowing engines are so designed that they can be operated at any pressure up to 30 pounds per square inch. The gas and air cylinders of the engines are situated at opposite ends of the main engine frame. Eight of these engines were built by the Westinghouse Machine Company and eight by the Allis-Chalmers Company.

In connection with the works of the Indiana Steel Company is a large central power station, 966 feet long and 105 feet wide, containing forty-two 23-foot bays. The station is advantageously placed as to fuel supply and with regard to minimum lengths of transmission lines to the various departments of the mills which use electric power. In this station there are installed seventeen horizontal, twin-tandem, double-acting gas engines, having a rating of 4,000 horse-power each and connected to generators of 2,000-kilowatt, normal capacity, but capable of carrying continuously 25 to 30 per cent overload. The engines turn at a speed of 83 1/3 revolutions per minute. Fifteen of the engines are designed for coupling to alternating current generators and two to direct current generators. The former are 25 cycle, 3 phase, 6,600-volt machines, while the voltage of the direct-current generators is 250. The engines described above are said to be the largest engines in the world to operate on blast furnace gas.

The occupation of this large field of power development by the gas engine has grown very rapidly during the last year. A heavily capitalized company has been formed in the iron-producing districts of England for the purpose of utilizing the waste gases from blast furnaces and distributing electrical energy to power users in various parts of England. The hitherto unprecedented scale upon which the United States Steel Corporation has entered on the use of power development by means of gas engines has created great interest in such installations all over the world. At the works of the Illinois Steel Company, South Chicago, are four gas engines of 4,000 horse-power, each direct connected to a 2,500-kilowatt alternating-current generator, and in one of the Carnegie plants, near Pittsburg, eight similar units are being installed.

The installations mentioned serve to indicate the immense field which gas engines are coming to occupy in one of the world's greatest industries, that of making steel.

The energy developed from blast-furnace gas by means of gas engines may be distributed for power and lighting purposes to distant points as well as used in the operation of the rolling mills in connection with blast furnaces, so that the latter become sources of power, serving various kinds of engineering enterprises.

Aside from blast-furnace gas, the gas produced from coal of various grades, and even from some lignite and peat, offers the most promising solution of the fuel question as applied to internal combustion engines of large size. It is safe to say that the most important work in developing satisfactory producers has been done in Germany, where large plants are in operation using cheap fuel and generating power at a surprisingly low cost. One of the chief lines of improvement during the past year or two has been in the methods used for cleaning the gas after it leaves the producer. When operated with high grade anthracite coal, there is very little tar in the gas coming from the producers, but when the cheaper grades of fuel are used it becomes necessary to employ special means in order to extract tar and dust from the gas. This is done in part by passing the gas through water chambers, or scrubbers, and in some cases by the use of what are called re-circulating producers in which the gas, after having been formed in the upper part of the producer, is led to the bottom of the bed of fuel by an external pipe and is caused to pass upward through the incandescent fuel in the bottom of the producer, after which it is taken off at a point about half way up the producer.

The application of internal-combustion motors to driving motor cars has undergone rapid development during the past year. No revolutionary discoveries have been made in this field during that time, but improvements in details have been continuous.

A new type of gasoline engine has been developed for motor-car propulsion by the Daimler Company, in which, instead of the usual poppet valves and gear, the inlet and exhaust ports are operated by means of sliding sleeves in which ports are cut. The sleeves are caused to move up and down between the piston and cylinder walls by means of eccentrics carried upon a shaft which is driven by chain gearing from the crank-shaft of the engine. The engine is said to run silently and well, even at low speeds, but it remains to be proved how successful it will be as regards wearing qualities and freedom from difficulties attending complex design. Another advance in automobile engine construction consists in arranging for the circulation of the cooling water on the thermo-siphon principle, with large flow and return pipes, instead of circulating the water by mechanically operated pumps. This change has been made on a number of recently designed engines. The design of automobile engines is continually advancing along lines of greater accessi-

* The Wisconsin Engineer.

bility and simplicity, more positive lubrication, and, in general, greater reliability.

Turning from the subject of internal-combustion engines, the generation of power by means of steam has undergone steady development, principally with regard to the steam turbine. The development has been along two lines: First, improvement in mechanical detail, leading to more simple construction and greater reliability, accompanied by more satisfactory methods of manufacture and the production of certain well-defined types of turbines. The most prominent types in use are, first, the Parsons, or many-stage reaction type; second, the Curtis, several-stage, velocity-compounded impulse type; third, the Rateau, several-stage, impulse type, compounded with respect to pressure only, instead of with respect to both pressure and velocity, as in the Curtis type. Based on the general principles of these three kinds of turbine, a large number of types more or less closely related to these has appeared, within the past six or eight years, each type bearing the name of its inventor.

The second line of improvement has resulted from better understanding on the part of designers of the heat changes that go on within their machines; that is, of the thermodynamics of steam flow in the various types of turbine.

Much remains to be done in steam turbine analysis, both from the mechanical standpoint, and from that of thermodynamics, but already many important improvements have been brought about. Some of these have been, the production of more homogeneous steel for turbine rotors; special material for blades, adapted to withstand the action of rapidly moving steam; such arrangement of parts as will permit of the use of superheated steam of high temperature without undue distortion, and consequent vibration and possible destruction of motive parts; better and more sensitive governing devices; and improvements in methods of supplying oil bearings. Besides these, methods of construction have been adopted in some types of turbine permitting larger working clearances between moving and stationary parts to be used without undue loss of steam leakage through the clearances. Five years ago, the largest steam turbine units built were designed for normal load of about 5,000 kilowatts. Now, units of from 10,000 to 12,000 kilowatts are not uncommon.

At present one of the most promising fields in power development is that in which the reciprocating steam engine and the turbine are combined; the engine using high-pressure steam of from 150 to 200 pounds per square inch by gage and expanding to about atmospheric pressure, the turbine using the exhaust from the engine and expanding it to a vacuum pressure of about one pound absolute, or, in some cases, one-half pound. Combinations of this sort are being used both for stationary power purposes and for the propulsion of vessels. The results are improvement in economy of fuel, in the amount of power developed per unit of weight and space occupied, and, in the case of marine work, the combination gives greater facility in maneuvering vessels, and greater economy at slow speeds than is possible in an all-turbine installation. Some of the largest vessels ever built are at present under construction at Belfast, Ireland, for the White Star Line, to be equipped with this combination system, which is the result of several years' experience in the application of the turbine to marine propulsion. During this time the giant Cunarders "Lusitania" and "Mauretania," with an all-turbine arrangement yielding 65,000 horse-power, and driving the vessels at 25 knots speed, have been in service. They have been remarkably successful considering that they were more or less in the nature of experiments in a hitherto untried field. It is significant that vessels of similar type, designed in the light of experience, are being equipped with the combination system.

With the development of the steam turbine, has come the necessity for measuring the power it delivers. This necessity has brought forth the invention of the torsion-meter. Heretofore, indicated horse-power, calculated by means of diagrams showing the pressure existing in steam-engine cylinders, has been the universally accepted standard for comparing the output of steam engines. A steam turbine cannot be "indicated." It can be tested by means of a brake, and the result is what is known as "brake horse-power." But a brake is difficult to apply to a shaft, under the conditions usually existing, especially on ship board. As is often the case, an investigation begun with one specific object in view yielded two-fold results. That is, Mr. Herman Frahm, of Hamburg, was commissioned to find out why marine engine shafting so often broke under the turning effort put upon it. A determination of the extent of angular distortion of the shafting under known turning efforts was part of the information necessary to his investigation. Having obtained means for measuring this, it was only a step to working the inverse of this problem, namely, if the angle of torsion of a given shaft the elastic properties of which have been determined by experiment be ascertained by measurement, when turning at a given speed, how much power is being delivered by the turbine or other engine, which is causing the shaft to rotate? As soon as the nature of the problem was recognized, instruments were devised for measuring the angle of torsion of shafting in motion, and such instruments are called torsion meters. Some of them are automatic recording devices, some indicate delivered horse-power directly on a dial, while others depend for their record upon sounds transmitted by the telephone. The results of this invention have been far-reaching. Not only can the power delivered by turbines be measured, but that of reciprocating engines can be equally well determined, and this latter, combined with information as to the indicated horse-power, has enabled engineers to solve the vexed problem as to the mechanical efficiency of large reciprocating steam engines. It had been customary to assume this efficiency at from 85 per cent to 90 per cent, with the emphasis on the 85 per cent. The torsion meter has shown it to be nearly 95 per cent. That is, that a well designed reciprocating steam engine of large size delivers perhaps 94 per cent or 95 per cent of the power given up to it by the steam working in the cylinders, instead of from 85 per cent to 90 per cent, as was formerly assumed. This has been one of the recent great achievements in mechanical engineering.

Another notable improvement has been the development of more satisfactory apparatus for producing superheated steam, for use in turbines and other engines, and resulting in greatly improved economy.

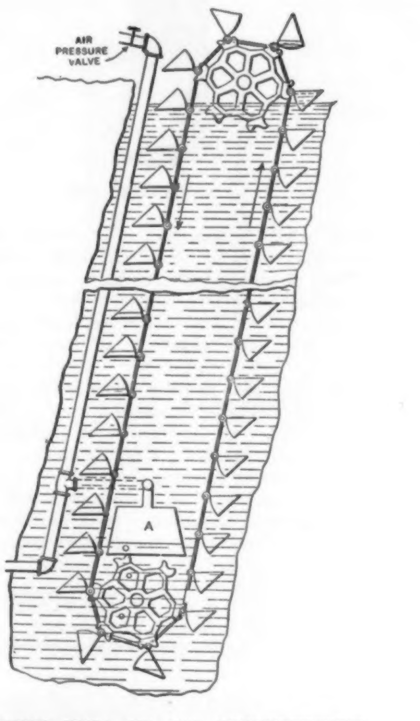
Again, the turbine has called for a better vacuum in the condenser receiving its exhaust steam, and this requirement has been promptly met by the production of condensers very much more efficient than have ever before been constructed.

In certain cases internal-combustion engines and steam turbines are being installed together, in electric power stations, with a view to obtaining cheaper power than is available from either steam or gas engines alone. The heat of the gas-engine exhaust, and that from the cylinder jackets, may be used for heating the feed water for the boilers supplying steam to the turbines. Where the gas engines can be fed with producer gas made from low-grade fuel, or where natural gas is available and cheap, the economy of the gas engine is such as to render it a very desirable element in the power station. But when the cost of gas is high, the advisability of installing gas engines is very questionable. In any event, where the combination system is used, the steam turbines, or else reciprocating engines, are used to take care of variations in load coming on the station, as the latter are very much more easily governed during wide variations of load, than are the internal-combustion engines. The latter are especially suited to carrying constant loads, while a steam turbine will take care of sudden variations from zero load to full load, with very little variation in speed of revolution.

The proposal so often made, to apply producers and internal-combustion engines to the work of ship propulsion, has been tested by the installation on the British ship "Ranger," in use by the Clyde Brigade of the British Naval Volunteers. This vessel has made long cruises, with satisfactory results, from the points of view of maneuvering and of fuel economy. There exists at present considerable difference of opinion in engineering circles as to whether the producer-engine combination or the engine using liquid fuel will be best adapted to the propulsion of large ships. Of course, the general question as to the practicability of applying internal-combustion engines to large ship propulsion is still open, it cannot be said to be near solution at the present time. For relatively small vessels, up to about 125 or 150 feet long, gasoline engines are being successfully used and are very satisfactory owing to the lightness of the machinery and the readiness with which a boat so fitted can be got under way. It is probable that the use of gasoline engines in marine work will be confined to relatively small ships, the heavier internal-combustion engines using either producer gas, or else the heavier oil fuels, being preferable for large installations aboard ship.

No account of even the most impressive recent improvements in mechanical engineering would be at all comprehensive if it failed to mention the great progress that has been made in the art of cutting metals; or, in other words, in the art of producing high-grade tool steel. A few years ago, one of our greatest steel works, turning out machine-finished products as well as the raw material, was facing the apparent necessity of doubling the size of its buildings and general equipment in order to cope with its growing business. At the critical time, the problem was met in an unexpected manner. Instead of enlarging the works, some bright fellow found a way to make tool steel that would maintain a cutting edge when taking off metal in a lathe or other machine tool at double the rate of speed formerly used. It was thus possible on the same floor-space to turn out about twice the work formerly produced. This improvement, however, could in many cases be taken advantage of only by replacing the machine tool equipment with new and stronger machines. The introduction of what are called "high-speed tool steels" at once became general. The advantage to large as well as small concerns was unquestionable. It has been followed by the appearance of many brands of special steels, each claiming superiority because of certain special properties conducive to the rapid cutting of metals.

There have been many other important developments during the past year or two, such as improvement in steam locomotives, which has undoubtedly been stimulated by the increasing application of electric traction in fields formerly occupied by steam locomotives alone; proposed mono-rail transportation; advance in submarine boat engineering; and the vast array of improvements in electrical engineering.



A NEW IDEA IN AIR COMPRESSION.

A NEW IDEA IN AIR COMPRESSION.

By JOSEPH H. HART.

THE accompanying illustration shows a system of air compression which may become useful under certain circumstances. In the engraving, merely the principle is shown, some mechanical improvements being possible of introduction in a commercial apparatus not being indicated. The construction of this device is very simple. It consists of an endless chain of buckets moving over two cog-wheels, the apparatus being almost entirely sunk under water. The buckets on the left-hand side turn their openings downward when moving in the downward direction, and are thus filled with air when they strike the surface of the water. During the downward movement of the buckets the air inside of them is compressed, as indicated by the double lines on the lower buckets on the left-hand side, the pressure on the air depending simply on the depth of the buckets below the surface of the water. When the bucket comes to the lower cog-wheel, it is turned around and the air escapes, being then collected into a hood *A* where it will be under pressure corresponding to the hydrostatic pressure of the water at the point at this depth below the surface. At the top of the mechanism the water is carried from the surface to the upper level of the wheel, and when the buckets are reversed, the water is dumped, and the buckets again filled with air. The raising of the water from the surface to the place where it leaves the buckets represents one of the losses of the mechanism. This loss remains approximately constant for all conditions, and expressed as a percentage of the total power required, it decreases as the depth of the device, and in consequence the compression increases.—The Mining World.

According to Engineering-Contracting, April 7th, 1909, the record for daily excavation in the central division of the Isthmian Canal was broken February 27th, 1909. On that day 59 shovels excavated 77,064 cubic yards, an average of 1,306 cubic yards per shovel for the eight-hour day. The material excavated was loaded in 2,177 Lidgerwood flats, 352 large western dump cars, and 2,754 small western and Oliver dump cars, a total of 5,283 carloads.

THE REPAIR OF FARM EQUIPMENT.—II.*

IDEAS FOR THE HANDY FARMER.

BY W. R. BEATTIE.

Concluded from Supplement No. 1743, page 343.

MISCELLANEOUS TOOLS.

There are a number of tools adapted to the handling of both wood and metals required in general repair work about the farm.

Tinners' Snips.—A small pair of tinners' snips, or shears, is desirable for cutting all kinds of sheet metals that may be required either for repair or construction work. The size of these shears is determined by the length of their jaws in inches. A 2½ or 3-inch size is desirable and should cost between $1 and $1.50.

Small Vise.—A small bench or table vise having about a 2½-inch jaw is useful for many purposes, especially where the objects to be held are quite small. This tool is also desirable for mending harness in case a regular harness clamp is not available. A vise of this character will cost all the way from 50 cents to $1.50, according to size and quality.

Dividers.—The little implement known as dividers, or compasses, is desirable for drawing circles or segments of circles in the making of special parts of machinery from wood. The cost of a pair of dividers with a segment and set-screw for setting to any angle should not be more than 60 cents.

Pliers.—Some form of pliers for working wire is essential. Besides their use for handling wire a good pair of pliers is desirable for a great many lines of repair work. There are a number of styles of pliers on the market, but one of the simpler types (Fig. 18) will give the greatest amount of service. As a rule a very serviceable pair of pliers can be secured for about 60 cents.

Cutting Nippers.—A pair of heavy cutting nippers with circular jaws is useful for many purposes, especially for removing a shoe from the foot of a horse or for trimming the edge of a broken hoof. Where a horseshoeing outfit is maintained, the cutting nippers will be included.

A Crowbar or Pinch Bar.—A crowbar or pinch bar will be found useful on the farm for prying or moving heavy objects. Where stones are to be removed from the soil a bar of this character is almost indispensable. A bar for general purposes weighing about 20 pounds will cost from $1 to $1.50.

Maul, or Beetle.—A maul, or beetle, can be hewn from a gnarly piece of hickory or gum. The head portion of the maul should be about 9 inches in length and 6 or 7 inches in diameter. Through the middle of this block a hole about 1¼ inches in diameter is bored and a shaved hickory handle inserted, forming a mallet weighing 16 to 25 pounds. If extra-heavy work is to be done, the head can be reinforced by means of iron rings, which are put on while hot and shrunken into place. This tool is desirable for driving heavy stakes and similar work.

Grindstone.—The farm repair outfit will not be complete unless some form of grindstone is included. The old type of stone with its wooden shaft, crank, and bearings has largely been replaced by the light-running treadle grindstones. No part of the repair work is so important as the keeping of tools in good order, and proper facilities for sharpening are essential. A good stone, mounted ready for use, will cost about $3.50.

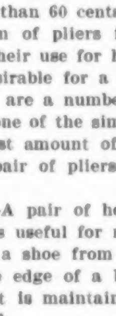


Fig. 18.—PLIERS.

Oilstone.—The oilstone is a necessary adjunct to the grindstone, its use being to put a smooth edge on the tools after grinding. Chisels, the bits of planes, and similar tools require grinding only occasionally, but may be sharpened quite frequently on the oilstone, and a fine cutting edge maintained. Instead of water, use kerosene or any light oil on the oilstone and wipe off clean when through sharpening. Oilstones can be bought at prices from 60 cents to $1.

Oiler, or Squirt Can.—This device is a convenience about the shop, both for oiling machinery and for keeping tools in order. A small oiler is desirable for use in connection with the oilstone. A can of this character will cost from 10 to 40 cents, according to quality. In purchasing an oiler care should be taken to secure one having a folded seam where the bottom is joined to the main portion, as a soldered seam is liable to give out in a short while. It is also essential that the bottom should have plenty of "spring" to force the oil from the spout.

Wire Stretcher.—On farms where wire fencing is employed it will be necessary to provide an appliance for stretching lines of wire. For light work, where short runs of single wire are to be handled, one of the hand-lever stretchers will be found most satisfactory. This tool consists of a wood lever about three feet in length, about one-third the distance from one end of which is attached a pair of grips or pliers to hold the wire. The wire is gripped in the holder, the short end of the lever passed around the post, and the power applied to the handle. A stretcher of this type can be purchased for about 75 cents.

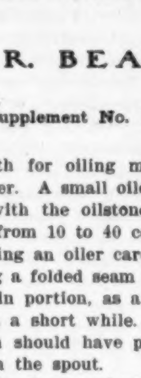


Fig. 19.—RIVET SET.

Another form of stretcher consists of a wire grip to which is attached a ring through which an ordinary crowbar may be passed to serve as a lever. This type of grip is obtainable for about 50 cents.

Staple Puller.—A staple puller is essential to the repair or alteration of wire fencing. An old mower guard will serve for this purpose, but a more satisfactory device may be constructed from a piece of ⅝-inch steel rod, about 15 inches in length, by drawing one end to a point, then turning about 1½ inches of this point at a right angle to the main portion. In using this tool the point is driven behind the staple by means of a hammer, then by a prying movement the staple is easily drawn. The handle end of the clawbar (Fig. 4) may be shaped for use in drawing staples.

HARNESS-REPAIR OUTFIT.

The tools and facilities required for keeping harness in repair are comparatively simple and inexpensive. Many of the parts of harness, together with convenient supplies with which to make repairs, are now offered at reasonable prices by dealers everywhere. A considerable portion of the repair work on harness can be performed by the aid of tools required for other purposes, but there are a few special devices that are desirable.

Leather Punch.—A good leather punch is one of the most desirable implements both for repair work and for making alterations in harness to fit animals of different sizes. A leather punch made somewhat on the order of a pair of pliers and having four or more punching tubes of various sizes is most desirable. It can be secured for about 40 cents.

Rivet Set.—A rivet set is especially desirable for use in connection with solid copper or coppered steel rivets. This (Fig. 19) is made of a small piece of tool steel and is provided with a small hole for driving down the washer on the rivet, also a countersink for expanding the end of the rivet.

Riveting Machines.—There are upon the market several kinds of lever devices for use in the insertion of hollow or tubular rivets in leather. These riveting machines are comparatively cheap, but as a rule the hollow rivets do not hold so well as the solid rivets.

Awls.—For the repair of driving harness there should be kept on hand one or two awls to be used in making the holes for sewing with a waxed thread. Awls of this character can be purchased for about 10 cents each, including handle.

Harness Clamp.—A clamp of some character is desirable for holding parts of harness while repairs are being made upon them. For this purpose a small table vise may be employed or a regular steel or wooden clamp may be purchased. A very serviceable home-made clamp may be constructed from two pieces of wood shaped somewhat like the staves of a barrel; at one end these pieces are dressed off so that they will fit together like the jaws of a vise, and the opposite ends may be hinged together or they may be fastened firmly to the sides of a base block. A short distance from the clamping end a screw, a bolt, a leather strap, or some other simple device may be used to draw the jaws tightly together.

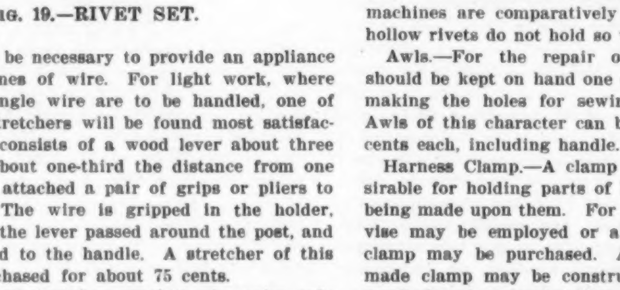


Fig. 20.—CROSS-SECTION OF WORKBENCH.

A, planing stop; *B*, bench screw.

SPECIAL CONVENIENCES.

In addition to the outfit of tools obtainable from a hardware dealer, there are a number of special devices that may be made on the farm and which will prove

* Reprint of Farmers' Bulletin 347, published by the Department of Agriculture.

of great assistance in general repair work. Among the more important are the following:

Workbench.—A workbench of some kind will probably be the first essential. A good type of workbench is shown in the foreground of Fig. 21; also in cross section in Fig. 20. For the construction of this bench there will be required four boards seven-eighths inch thick, 12 to 14 inches wide, and about 12 feet in length. The length of the bench, however, will depend upon the size of the shop or other space that may be available for use as a workroom. Two pieces of 2 by 4 inch scantling, each 16 feet long, will be sufficient to construct the framework of the bench. All lumber entering into the construction of the workbench should be thoroughly seasoned and dressed to uniform width and thickness.

A clamp for holding materials should be constructed from a piece of hard wood and attached by the aid of a carpenter's bench screw, as shown in cross section in Fig. 20. This clamp should be provided with notches or pin holes at the lower end, so that it can be set to hold materials of any thickness. Along the front of the bench, two or three holes should be provided, into which pins may be set for supporting boards or other materials that are too long to be held rigid by the clamp alone.

A "stop" for holding materials that are to be planed can be inserted in the top of the bench, near the left-hand end, as shown in Fig. 20. If a regular stop is not employed, its place may be taken by a small piece of notched board nailed on top of the bench.

Sawhorses.—A pair of trestles, or sawhorses, each consisting of a piece of 2 by 4-inch or 2 by 6-inch timber, about 4 feet in length, supported upon four legs, as illustrated in the foreground of Fig. 21, are very convenient for working upon while marking, sawing, boring, or chiseling. The sawhorses are an accessory to the workbench and should be constructed at the same time. The cost of materials with which to construct both the workbench and sawhorses should not exceed $5.

Miter Box.—Among the accessories to the workbench there is perhaps no device that will give greater satisfaction than a good miter box to be used for sawing small wood materials either square or at an angle. For the construction of a miter box, three pieces of board 1 inch thick, 6 inches wide, and 3 feet in length should be selected and nailed together in the form of a square trough, taking care that the nails are driven well out toward the edge of the boards. Vertical cuts are sawed down through the sides to the bottom board to guide the saw when the box is in use. Near one end a cut is made at right angles with the length of the box to be used in making square cuts. For making bevel cuts for a right-angled miter joint, the sides of the box should be sawed down on oblique lines running at an angle of 45 degrees with the length of the box. Two such cuts should be made and should cross each other at the middle of the box, forming a letter X. In marking the box to make these cuts, the square should be laid flat on top of the box so that its corner is flush with the outer edge on one side, and each arm reaching obliquely across the box will show exactly the same number of inches to the outer edge on the

Fig. 21.—INTERIOR OF WORKSHOP WITH $25 OUTFIT OF TOOLS, A WORKBENCH, SAWHORSES, AND MITER BOX.

other side. When the square has been correctly placed, mark along one arm for one of the cuts; then reverse the position of the square and mark for the other cut. A miter box is shown on top of the workbench in Fig. 21.

COMBINATION TOOL OUTFITS.

For the benefit of those contemplating the purchase of tools for use on the farm the following combinations are suggested. In making up these lists of general-purpose repair tools the better grades have been placed in the higher priced sets, although those included in the cheaper outfits should be of good and durable material.

A $2.50 Outfit.—A hatchet, a handsaw, a small square, a screwdriver, and a pair of pliers.

A $5 Outfit.—A hatchet, a 26-inch handsaw, a small steel square, a drawing knife, a brace and four bits (¼, ½, ¾, and 1 inch), a pair of pliers, a screwdriver, a cold chisel, a flat file, and a monkey wrench.

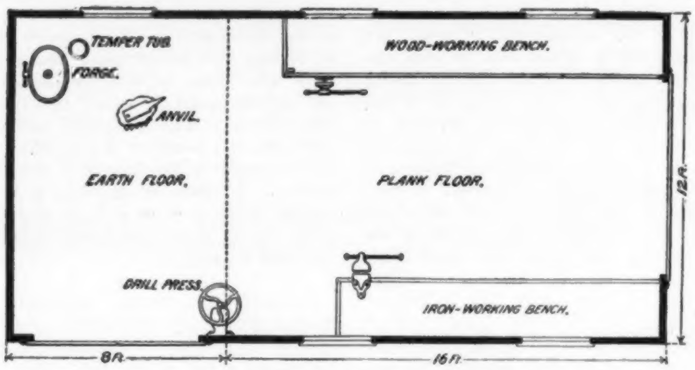


Fig. 22.—FLOOR PLAN OF WORKSHOP.

A $10 Outfit.—A hatchet, a hand ax, a 26-inch handsaw, a 24-inch steel square, a drawing knife, a brace and six bits (¼, ⅜, ½, ⅝, ¾, and 1 inch), a pair of pliers, a screw-driver, a cold chisel, a 12-inch flat file, a monkey wrench, a jack plane, 2 chisels (½ and 1 inch), a rivet punch, a riveting hammer, a leather punch, and a small oil can.

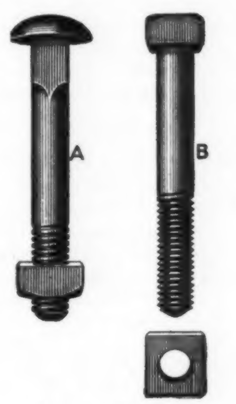


Fig. 23.—BOLTS.

A, Carriage bolt; *B*, machine bolt.

A $15 Outfit.—An ax with handle, a hand ax, a hatchet, a 26-inch handsaw, a 24-inch steel square, a drawing knife, a brace and six bits (¼, ⅜, ½, ⅝, ¾, and 1 inch), 3 twist drills (3/16, ¼, and ⅜ inch, with square shank to fit in carpenter's brace), a bit gimlet, a screw-driver, a jack plane, a pair of pliers, 2 chisels (½ and 1 inch), an auger (1½ inch, with handle), a small vise, a cold chisel, a monkey wrench, a rivet punch, a claw hammer, a riveting hammer, a leather punch, a compass saw, a spirit level, an oil can, a 12-inch flat file, a 12-inch wood rasp, 2 small three-cornered files, a 2-foot folding rule, a chalk line, and a ball of chalk.

A $20 Outfit.—To the list given for the $15 outfit, add the following: A 26-inch ripping saw, a spokeshave, a bevel square, a scratch gage, a pair of dividers, a small try square, a scratch awl, 2 twist drills (½ and ⅝ inch), an oilstone, and a pair of soldering irons.

A $25 Outfit.—To the list given for the $20 outfit add the following: A small steel square, an alligator wrench, a hack saw, a 10-inch pipe wrench, a pair of tinners' shears, a ratchet brace instead of a plain brace, a rivet set, additional bits to make a full set of 12 (¼ inch to 1¼ inches by eighths and sixteenths), and a smoothing plane. A $25 outfit is shown in Fig. 21.

IRON-WORKING AND SHOP EQUIPMENT.

Blacksmithing Tools.—A blacksmith's outfit adapted to the requirements of a large farm should include a forge, an anvil, a 2-pound hammer, an 8-pound sledge, a riveting hammer, two pairs of tongs, an assortment of punches, hot and cold chisels, anvil hardie, cutting nippers, coarse files, screw plate, vise, drill press with drills, and a monkey wrench. The cost of this outfit may be as low as $30 or as high as $60 and upward, according to the class of materials selected. "Combination outfits" consisting of the above tools are offered at these prices, but if the outfit is made up by selecting from the general stock of a dealer, the price paid will be much greater.

Shop Equipment.—The complete equipment of a shop for the making of general farm repairs should include the above blacksmithing outfit, the $25 collection of wood-working and general-purpose tools, a pipe-working combination, miscellaneous tools, harness-repair outfit, a workbench, a pair of sawhorses, and a grindstone. This entire equipment for a shop can be secured for about $100 in a fair quality of goods, and for $150 tools of excellent quality can be obtained.

SHOP FACILITIES FOR REPAIR WORK.

A shop or other suitable place where repair work can be carried on during cold or stormy weather is almost as important as the tools and materials with which to make the repairs. A small building devoted exclusively to shop purposes is desirable, but where this is not available a portion of one of the regular farm buildings may be utilized. One side of a wagon shed can frequently be devoted to this purpose. A workbench can be fitted up and provision made for the care of tools and supplies.

Plan of Workshop.—A shop which meets the requirements of the general farm is illustrated by the floor plan shown in Fig. 22. The shop from which this plan was taken consists of a one-story building about 24 feet in length and 16 feet in width, having a plank floor over about two-thirds of its area, the remainder with an earth floor being used as a blacksmith shop. The floored portion was provided on the one side with a wood-working bench, over which were placed several shelves for the reception of tools. On the opposite side there was provided a heavy plank bench with a vise and other equipment for working iron. Below the iron-working bench there should be provided a rack upon which to store the stock of various sizes of square and round iron required for making repairs. Above the iron-working bench there should be a few shelves for the storage of tools; also numerous pigeon-hole boxes for the accommodation of the stock of bolts, nuts, and washers.

This shop was constructed of cheap lumber, the siding being put on up and down with cracks battened, and it has a simple gable roof. By this type of construction ample space is secured overhead for the storage of materials, especially seasoned timber for use in making repairs. An abundance of light is essential to good work, and as much of the repair work will be done during dark and cloudy weather, the windows should be numerous and so distributed as to provide for uniform lighting. The windows should be protected on the inside by wire netting.

The large doors in the end of the shop are made to cover the entire space between the workbenches, so that the larger farm implements may be brought upon the floor for repairing. Where the climate is cold, provision should be made for a heating stove, in order that the shop may be comfortable for work during winter weather. If a portion of a wagon shed or other

farm building is set aside for shop work, it should, so far as practicable, be fitted as a regular shop.

The Care of Tools.—The system of storing the tools should conform to the needs of those using them and to the work to be performed. In many instances it may be desirable to keep the tools in a portable chest in which they may be carried to any part of the farm or plantation; on the other hand, if the work is done almost entirely at the shop the tools will be more accessible when supported on the walls or upon shelves above the bench.

In climates where the atmosphere is moist the greater part of the time, it is not wise to keep the tools exposed by hanging them on the walls or laying them upon open shelves, but a wall cabinet or a tool chest should be provided. It should be the aim to have a place for every tool, and then cultivate the practice of returning it to its proper place immediately upon the completion of the work in hand. A very good plan for keeping the tools in their respective places is to first draw an outline of each tool in its place upon the wall and then paint this space black or some color in contrast with the wall itself, so that when any tool is not in its place its absence will be readily apparent.

Many persons are in the habit of leaving tools where they finish using them. In the first place, a tool can not be kept in working condition if allowed to remain exposed to the weather, and in the second place the time lost in locating the tool when it is next required for use will be much greater than that which would be required to return it to the proper place.

MATERIALS REQUIRED FOR GENERAL REPAIR WORK.

However complete the tool equipment, it will be of little use without a supply of materials with which to replace worn or broken parts of machinery and implements. The time required to secure stock materials may be as great as that necessary to have the repairs made in the nearest shop. A supply of timber, bar iron, bolts, rivets, screws, etc., should be kept constantly on hand and renewed from time to time as the stock runs low.

WOOD MATERIALS FOR REPAIRING FARM EQUIPMENT.

The supply of wood for use in making repairs should be well seasoned and dry. It should include split hickory, ash, and oak, from which handles, singletrees, doubletrees, neck yokes, and similar articles can be made. Split timber is better than sawed for these purposes, owing to the straight grain when the wood is split. Sawed oak, ash, or heart pine, in sizes 1 by 2, 2 by 4, 2 by 6, 3 by 4, 3 by 6, 4 by 4, and 4 by 6 inches, and 14 or 16 feet in length is frequently required for use in replacing broken handles, braces, tongues, axles, etc. It is also desirable to have on hand a small stock of white pine, one-half and seven-eighths inch in thickness, for use in repairing or replacing the lighter wood parts of implements.

A great variety of wooden parts for farm implements is kept in hardware and general supply houses. On large farms it is advisable to keep on hand one or two each of the following: Ax handles, hatchet and hammer handles, hoe and rake handles, fork handles, shovel handles, singletrees and doubletrees, wagon tongues, carriage poles, and buggy and wagon shafts.

It should be the practice to save every small piece of good material and store it in a dry loft or other convenient place. A good piece of a thin board can frequently be saved from a broken packing box, and this will serve as well as new material for repair work. It should be the policy to save every good barrel hoop or extra barrel head for future use in replacing a broken or missing one. Very little time will be required to care for these articles if some system of storing them is employed.

METAL MATERIALS FOR REPAIRING FARM EQUIPMENT.

Bar Iron.

Where a regular blacksmith outfit is maintained the supplies kept on hand should include a stock of both round and square iron. The bars come in lengths of about 14 feet.

Round Iron Bars.—The stock should include the following: ¼, ⅜, ½, ⅝, and ¾ inch, three to five bars each, and one bar 1 inch in diameter. The ⅜ and ½ inch sizes are most frequently needed.

Rectangular Iron Bars.—The stock should include the following sizes: ⅛ by ¾ inch, ⅛ by 1, ¼ by 1, ¼ by 2, ⅜ by 1, ⅜ by 1½, ⅜ by 2, ½ by 1, ½ by 1½, ½ by 2, and ½ by 3 inches. The greatest demand will be for ¼ by 1 inch, ¼ by 2, ⅜ by 1½, and ½ by 2 inches, and of these sizes three or four bars should be secured. Of the other sizes one or two bars will usually suffice.

T-Bars and Angle Iron.—These in sizes up to 2½ inches are very useful for making repairs on harrows, cultivators, and other implements in the construction of which such iron has been used.

The price of bar iron varies with the market, but it is usually less than $3 per hundredweight.

Iron Bolts.

For the convenience of intending purchasers, a list of bolts is given. The sizes most needed in repair work are indicated by the larger numbers suggested. For information concerning prices, dealers or their catalogues should be consulted, as the prices vary with locality and market conditions. Bolts, screws, and rivets can be secured at a great reduction if purchased in original packages containing 50 or 100, or a gross, as the case may be.

Carriage Bolts.—As a rule the round-headed or carriage type of bolt is best adapted for use in wood or where wood and iron are bolted together. Whenever a nut is being drawn down upon wood, a washer should be placed beneath it. A hole bored for the insertion of a carriage bolt should not be more than one-sixteenth inch larger than the bolt, as the square shank of the bolt should be driven solidly into the wood to prevent its turning. The difference between machine and carriage bolts is shown in Fig. 23.

The supply of carriage bolts should include the following: 100 each of ¼ by 2, ¼ by 3, and ¼ by 4 inches; ⅜ by 2, ⅜ by 3, ⅜ by 4, and ⅜ by 6 inches; ½ by 1½, ½ by 2, ½ by 4, and ½ by 6. Of the following sizes a dozen each should be secured: ½ by 8, ½ by 10, and ½ by 12 inches.

Machine Bolts.—These have square heads but the shanks are round throughout. For bolting together iron parts, they should always be used. The following will make a fair supply for a farm: 100 each of ⅜ by 2 and ⅜ by 4 inches; ½ by 1½, ½ by 2, ½ by 3, ½ by 4, and ½ by 6 inches; ⅝ by 2 and ⅝ by 4 inches. A dozen each of the following should be included: ½ by 8 and ½ by 10 inches; ⅝ by 6, ⅝ by 8, and ⅝ by 10 inches; ¾ by 3, ¾ by 4, ¾ by 5, ¾ by 6, ¾ by 8, ¾ by 10, ¾ by 12, and ¾ by 14 inches.

Tire Bolts.—Bolts either 3/16 or ¼ inch in diameter and from 1½ to 2 inches in length are most used. Examine the wheels of the vehicles which are to be kept in repair, and get two or three dozen of each size of bolts needed. A few felly plates should be included.

Extra Nuts.—To replace lost nuts, the following should be included in the stock: 25 each of ¼, ⅜, ½, ⅝, and ¾ inch sizes.

Washers.—For use with bolts and rivets, get 2 pounds each of the ¼ and ⅜ inch sizes, and 5 pounds each of the ½ and ¾ inch sizes.

Rivets, Screws, Nails, Etc.

Iron Rivets.—For most purposes rivets with small round heads or with broader flat heads are used. The sizes most needed are 3/16 and ¼ inch in diameter and ¼, ⅜, ½, ¾, and 1 inch in length. From a half pound to a pound of each size will be an ample supply. Rivets with countersunk heads are used for some purposes, and a few of the different sizes should be secured; also a few of the special rivets used in repairing mower and reaper knives.

Wood Screws.—Screws are classified by number and length, the number referring to the diameter. They are put up in boxes each containing one gross. A gross each of the following sizes should cost about $2, and will meet all ordinary demands: No. 6, of ¾ and 1 inch lengths; No. 8, of 1, 1¼, and 1½ inch lengths; No. 10, of 1¼, 1½, 1¾, and 2 inch lengths; and No. 12, of 2 and 2½ inch lengths.

Nails.—Of flat-head wire nails, 5 pounds each of 3, 4, 5, and 6-penny sizes and one keg (100 pounds) each of 8, 10, 20, and 40-penny sizes should be obtained. Nails purchased in small quantities will cost 4 and 5 cents a pound, but if secured by the keg the cost is generally below 3 cents a pound. For certain purposes, such as the laying of floors and the construction of partitions from matched lumber, the square cut steel nails are considered desirable. Wire brads of various sizes and lengths are useful for both repair and construction work, and a few of these of different sizes should be secured.

Staples.—Of the standard size used in the construction and repair of wire fencing, 10 pounds or more should be kept on hand; also a pound or two of the smaller sizes for fastening poultry netting. Small staples, known as "double-pointed tacks," are useful for tacking fly screen over windows and for many other purposes.

Strap Hinges, Clips, Wire, Tin, Etc.—On farms that are at a distance from a hardware store, a few pairs of strap hinges of 3, 4, 6, 8, 10, and 12-inch lengths should be kept in stock. Hooks and staples or iron latches for fastening gates and barn doors may also be included in the hardware list. Clips for singletrees, doubletrees, and neck yokes are offered by dealers at prices far below the cost of having them made at a local shop. Other materials that may often prove useful are small copper wire, annealed wire, galvanized wire, hoop iron, galvanized sheet iron, and sheet tin.

SUPPLIES FOR REPAIR OF HARNESS, CARRIAGE TOPS, ETC.

Every farmer should have on hand supplies for the repair of harness, and many will find it an advantage to have also some materials for making the simpler repairs on carriage and buggy tops. Ready-made harness and bridle parts of all kinds can be secured from many of the larger establishments.

Harness Rivets.—The solid rivets for harness repairs are either of copper or coppered steel, the former costing about three times as much as the latter. They can be bought in boxes containing assorted lengths ranging from one-fourth to three-fourths inch.

Leather.—By visiting a regular harness shop, it is often possible to secure at a small cost scraps of harness leather that will prove very useful in making repairs; but where the amount of repairing to be done is large, the purchase of a whole side of good harness leather is advisable.

Harness Hardware.—The supplies of this class most often required are buckles of various sizes, snap hooks, bridle bits, hame staples, hame clips, cockeyes, open links, and rings of different sizes.

Other Materials.—The outfit should also include thread, beeswax, extra awls and needles, carriage washers, knobs, and eyelets for carriage curtains, shaft tips, and harness oil. A broken shaft may often be made good with a metallic shaft end. There are also on the market a number of devices, known as "menders," for making quick temporary repairs to harness.

PAINTS, OILS, AND MISCELLANEOUS SUPPLIES.

For repainting the farm equipment the following supplies will be found useful: White lead, red lead, Venetian red, raw linseed oil, and turpentine. Ready-mixed paints can be used, but when made of good materials they are more expensive. For lubrication purposes there should be a supply of machine oil, axle grease, and castor oil. For miscellaneous purposes there will be required small quantities of liquid glue, rubber cement, solder, soldering fluid (prepared by adding metallic zinc to strong hydrochloric or muriatic acid), sandpaper, emery cloth, and twine.

SUGGESTIONS.

The lists contained in this paper include many things that will not be required on a large number of farms. Where specialized farming is pursued, only the tools and supplies with which to repair the special farm equipment will be required. The indiscriminate purchase of tools may result in direct loss.

In deciding what tools and materials to purchase, always give preference to those most frequently and urgently needed, passing over those that will be rarely used.

Keeping a machine or vehicle in good repair and well oiled not only increases its efficiency, but lessens the power required in using it.

The proper maintenance of farm machines not only saves money but avoids danger to those who operate them. Keeping the harness and vehicles in repair may prevent a dangerous runaway.

So far as practicable let the repair work be done when regular farm work is not pressing, as on rainy days and during the winter season. Pursue the repair work as a kind of recreation or rest from the regular farm operations.

Do not have several places for the storage of repair tools and supplies. Have one convenient place, and see that all tools are kept there when not in use.

Tools and materials should be kept in their proper places. Do not keep all sizes of bolts or screws mixed together in a single receptacle, but fit up suitable boxes or bins, so that the supplies may be accessible on short notice.

Keep all tools clean and free from rust, and all edge tools sharp.

AN OPTICAL PROBLEM.

A RATHER curious problem relating to combinations is referred to by the British Journal of Photography. It is one that is not usually dealt with in textbooks, for probably no writer has foreseen that it could be one of practical interest. Yet for some reason or other it is one that is continually cropping up. Stated generally, the problem is as follows: A lens is fixed at a given distance from a screen, which is not at its focus. A sharp image is, however, to be produced by the interposition of a second lens of given focal length between the first lens and the screen. Where should this second lens be placed, and what is the focal length of the resulting combination? We know the focal lengths of the two lenses, but not their separation, and therefore querists generally fail to find the focal length. A little consideration should, however, show that the separation can easily be determined from the usual formulæ. The distance from the front lens to the screen is known, and this obviously is equal to the separation plus the back focus; that is, the distance from the second lens to screen. In this equation the separation is the only unknown quantity, and, therefore, its value is easily determined, after which the calculation of the focal length is a simple matter. To take an instance, suppose the front lens to be a 6-inch positive, and the back one a 6-inch negative, while the distance from front lens to screen is 14 inches. If a represents the separation, the application of the usual formulæ will show that the back focus is equal to $\frac{36}{a} - 6$. This added to $a = 14$, which equation can be changed into $a^2 - 20a = -36$, and from this a must equal either 18 or 2. The former being impossible, 2 is the correct answer. The focal length can then be shown to be 18 inches.

COLOR PHOTOGRAPHY.

THE "OMNICOLOR" PLATE.

BY H. QUENTIN.

Our readers will recall the principles underlying the manufacture of polychrome plates for color photography. A brief summary of the main features of the method followed in the production of the "omnicolor" plate will therefore suffice here. The plates are prepared by treating a gelatine film (upon a glass plate) successively with certain reserves, coloring matters, and varnishes, thus producing a kind of mosaic of red and green rectangles and blue lines. The red and green fields are quite regular in form; the blue lines, on the other hand, show constrictions at constant intervals, corresponding to their intersection with the red fields. As a matter of fact, the red color is distributed in narrow red bands, and the blue lines superposed upon these, produce at the points of contact, a purplish violet color. As the two dyes used, the orange-red and violet-blue, have very little affinity for each other, the purple-violet occupies only a very narrow strip, and it is in this way that the blue lines acquire their characteristic wavy form. The green elements present on each side a lateral zone of lighter color, and verging on yellow. Counting in the purple fields (which transmit only a very small portion of radiation, from the extreme end of the spectrum) there are about 288 fields per square millimeter on the plate, say:

Orange red	72
Bluish violet	72
Green	72
Purple	72

The colors used differ appreciably from those employed in making the so-called "auto-chrome plates," the green tending more toward yellow, and the blue being less violet. The film thus prepared has a high degree of transparency, and is very strong. This latter quality is due to the thorough tanning action which the successive treatments have upon the film, rendering it absolutely insoluble.

These plates are sensitive to all colors of the spectrum, even in the extreme red. There is, however, a slight minimum in the green, of which advantage might be taken, using subdued green light or illumination in developing. In the blue and violet there is a maximum of sensitiveness, as in all gelatino-bromide emulsions. It is quite indispensable to compensate for this by interposing a yellow screen when making the exposure.

The light transmitted by the lens is to be analyzed by the polychrome patterns or mosaic before it reaches the sensitized layer of the plate. The latter must therefore be placed in the plate holder glass side forward, i. e., toward the lens. Thus the sensitized film is in contact with the back of the plate holder, and it is therefore advisable, in order to prevent scratches, to insert a piece of thin black pasteboard behind the plate. Another necessary precaution is to clean the glass side of the plate, before charging the holder, with a piece of linen, either dry, or moistened with a little alcohol. This is to remove the traces left by drops of water on the glass in the process of preparing the polychrome pattern. The plate holders must be charged in absolute darkness.

In using such polychrome plates, allowance must be made for the slight displacement in focus produced by the glass plate intervening between the lens and the sensitized film. The requisite correction may be made automatically, if the compensating screen is placed behind the lens. This will be the most convenient arrangement for cameras with fixed focus. On the other hand, in the case of cameras with rack and pinion focusing, the screen is best placed in front of the lens, and the ground glass focusing screen is turned with its polished side forward. Then the sensitive film, when in position in the plate holder, ready for exposure, comes exactly into the focal plane previously determined by focusing on the ground glass.

Proper regulation of the exposure is of considerable importance in all processes of color photography, for it is only by correct exposure that a true copy of the natural tints can be obtained.

Owing to the highly transparent character of the colored film, and the comparatively pale color of the compensating screen, the omnicolor plates are very rapid, so that on a bright summer's day a slow instantaneous exposure can be used, if a lens of large aperture is employed. The exposure must be about thirty times as long as for the green label Jongla plates.

For developing, the following hydroquinone-metol bath is recommended:

Distilled water	1,000 c. c.
Metol	4 grm.
Anhydrous sodium sulphite	50 grm.
Hydroquinone	2 grm.
Dry potassium carbonate	30 grm.
Potassium bromide	1 grm.
Sodium hyposulphite (1 per cent solution)	15 c. c.

The action of the bath varies very greatly according to the temperature, so that, in order to obtain good results, it is indispensable to keep the solution between 15 deg. and 18 deg. C.

If the temperature is too low, the bath does not act throughout the entire thickness of the film, and a flat negative is obtained. If on the other hand the temperature is too high, the bath is too active and destroys the details in the high lights. The normal time for development is about five minutes. A plate 13 x 18 centimeters requires 100 to 120 cubic centimeters of developer. The room must be completely darkened. The plate is carefully lifted from the plate holder, lightly brushed over with a camel's hair brush, and placed in the developer. The disk is rocked for a few seconds, and is then allowed to stand for about five minutes, covered with a piece of cardboard or with a second (larger) disk. The room may then be illuminated, preferably with green light. After three or four minutes the plate may be examined in this very subdued green light, provided this is done quickly, and at a distance of at least one meter from the lantern. When development is completed, the plate is washed for twenty to thirty seconds, to free it from excess of developer, which would retard the action of the next bath, consisting of:

Distilled water	100 c. c.
Sodium or potassium bichromate	8 grm.
Sulphuric acid	12 c. c.

This serves to dissolve off the reduced silver and to transform the negative image (with colors complementary to the true colors) into a positive with the natural colors. The plate is placed in this solution and rocked for a few seconds. From this point on the work may be carried out in white light. It requires about two minutes to dissolve off the silver reduced in the first developing bath. If the silver is not completely removed, then at the subsequent second developing operation described below, an image partly positive and partly negative, or sometimes a streaked effect, is produced. On the other hand, if the plate is left too long in the inverting bath, the half-tints and delicate colors are destroyed.

When the silver is completely dissolved (which is readily ascertained by examining the plate by transmitted light), the plate is carefully rinsed for about one minute, to remove the yellow flush of bichromate, and is then placed for a second time in the same developing bath as on the first occasion. This must be done in daylight, or at any rate in strong artificial light, such as incandescent gas light or magnesium light.

In this bath any silver bromide hitherto unattacked blackens, and the image gains in brightness and vigor. This development requires about four minutes in daylight and five to ten minutes in artificial light. If the development was not carried far enough, the image will lose in the fixing bath. This latter should be an acid fixing solution, in which the image will be found to gain in clearness and brightness of color. The plate should then be washed in running water for twenty to thirty minutes. Prolonged washing in no way harms the colors of the film, which are absolutely insoluble, and resist several hours' washing without the slightest alteration.

The plates may be dried, like ordinary plates, in a dry airy place sheltered from dust. In the process of manufacture of the omnicolor plates the gelatine film becomes very much hardened, and owing to this it is even permissible to dry them before a fire. This may be taken advantage of in case of urgency or when traveling.

It is advisable to coat the finished plate with the following varnish:

Dammar gum	15 grm.
Crystallizable benzine	100 c. c.

This varnish is applied in the same way as collodion. It is poured cold upon the plate, and the excess is allowed to run off at one of the corners, taking care to avoid streakiness.

The risk of failure is small, thanks to the simplicity of the operations involved. Nevertheless it may occur, through injudicious exposure, under or over-development, or incorrect temperature of the bath, that the result is imperfect, either in the color values or in transparency. Under-exposed plates show a general violet or reddish tint, according to the degree of under-exposure. A violet or blue color indicates altogether too short exposure, and in such cases there is no remedy. Plates showing a not too intense mauve or rose tint can sometimes be corrected by treatment with a dilute solution of Farmer's reducing agent (sodium ferricyanide and hyposulphite). This gives a weak image, which can be intensified by means of mercuric chloride or sodium sulphite. The result is an image with bright and transparent colors still, however, showing a mauve or rose tint. This latter may be neutralized by covering the plate with another plate, coated with a gelatine film of very light green tint. The plate must of course be carefully washed after treatment in the reducing and intensifying bath.

It is interesting to note how an under-exposed omnicolor plate selects colors: In copying a painting, for example, the blue and violet are first recorded, then the red, and finally the green. Brown, which is obtained as a mixture of green and red, will be represented by red if the plate is under-exposed, while green will appear as black. With normal exposure these anomalies vanish and the colors are rendered in their true values.

Plates developed at too low a temperature or for an insufficient time, like under-exposed plates, give flat images. The remedy is the same as described above. Over-exposed plates, on the other hand, or plates which have been carried too far in the first development, or developed at too high a temperature, lack half-tints: the delicate shades are completely swallowed up in the white.

This fault, if not too extreme, may, within certain limits, be corrected. The plate is laid in a bath of:

Distilled water	100 c. c.
Mercuric chloride	2 grm.
Sodium chloride	2 grm.

The image is bleached in this bath, washed very carefully for at least one minute, and fixed in a 5 per cent solution of sodium sulphite.

Presumably a developer will ultimately be found which is less sensitive to temperature changes than hydroquinone-metol. But in the meanwhile it is necessary to adhere strictly to the directions given.

It might at first sight be supposed that the geometrical pattern (mosaic) of the omnicolor plates might impair the harmony of the image. If, however, the latter is examined at the distance of distinct vision, say 20 to 25 centimeters, the interlacing pattern is absolutely imperceptible, and is completely fused up in the general color effect, which presents a truly remarkable softness and delicacy.—Translated for Scientific American Supplement from "La Photogr. des Couleurs."

The telerupter, or circuit breaker operated at a distance, is a new device which may be applied to the control of any lighting or other electric circuit which carries a current of 20 amperes or less. The circuit of the telerupter itself is composed of small wire, such as is used in electric bell circuits, and its current is furnished by sal ammoniac batteries. The device consists of a sucking coil with a vertical core or plunger carrying at its lower end two contact points which, in the lowest position of the plunger, dip into mercury cups and close the lighting circuit. When the telerupter circuit is momentarily closed by pressing a button at the distant station, the plunger is lifted by the coil and its points emerge from the mercury cups, breaking the lighting circuit. In the ascent of the plunger a pin attached to it causes a sliding piece to move in such a manner that when the plunger falls, in consequence of the breaking of the telerupter circuit by the removal of the finger from the button, the pin is caught in a notch high enough to hold the contact points above the mercury, so that the lighting circuit remains open. When the button is pressed again the plunger rises, lifting the pin from the notch, and the sliding piece is moved so that when the telerupter circuit is broken by taking the finger from the button the plunger falls to its lowest position, the contact points enter the mercury, and the lighting circuit is closed. The telerupter may be made in bipolar or tripolar form for the control of small motors from a distance.

AMMONIA SULPHATE FROM PEAT.

THE WOLTERECK PROCESS.

BY THE ENGLISH CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

Though the fertilizing properties of crude peat have long been recognized, its utilization in this capacity is strictly limited to those districts in which it can be immediately and cheaply secured, the low market value of the substance rendering transportation impossible upon a commercial basis. Yet, owing to its large percentage of nitrogen, efforts have been made to extract this quality in some concentrated form, such as its conversion into ammonia and subsequent recovery of the latter as sulphate of ammonia. These experiments have only met with moderate success, attributable to the fact that a large proportion of the ammonia was lost, so that the actual yield of the fertilizer from the amount of peat treated was so small as to render its cost greater than the marketable value of the product itself. Thus the production of sulphate of ammonia from peat has been regarded somewhat as a by-process in the manufacture of fuel or some other article. Recently, however, a well-known German chemist, Dr. H. C. Woltereck, has evolved a process in which the production of the ammonium sulphate is the staple article; and a small plant having demonstrated the commercial possibilities of the invention, a large one has been erected upon the extensive Irish peat bog at Carnlough.

The process consists in the passage of a mixture of air and water vapor over peat maintained at a low grade of heat in specially devised furnaces. In this manner the nitrogenous constituents of the raw material are completely evaporated, and the vapor or gas thus secured is afterward treated so as to yield the valuable volatile contents.

The two dominant features of the process are the design of the furnaces in which the moist combustion is effected, and the conversion of the nitrogen in the peat into sulphate of ammonia by moist combustion instead of by destructive distillation. The result of this latter characteristic is that the peat may have a heavy content of moisture which does not require preliminary elimination, thereby resulting in the dispensation of expensive hydro-extractors, while the cost is saved of driving off the moisture by evaporation. Although the recovery of the ammonium sulphate constitutes the basis of the process, other valuable products, such as the paraffine tars and acetic acid contained in the gases, are secured, the commercial value of which tends to reduce the cost of manufacturing the principal commodity.

At first Dr. Woltereck's investigations were confined to a small laboratory, followed later by those with a model plant laid down in a London suburb sufficient to enable one ton of peat to be treated per day. This plant was run continuously night and day for the greater part of a year to determine the practical possibilities of the process. Owing to the novelty of the system, the construction of the furnace entailed many speculative problems, and the first one proved a failure. The difficulties, however, were of a mechanical nature, the accumulation of the ash proving an apparently insurmountable problem. The experience gained in these tests resulted in the anticipation that only air-dried peat could be used. This would have entailed the adoption of the usual methods of cutting the peat into sods, and subjecting it to exposure in the sun and air. Inasmuch, however, as the Irish climate is particularly humid, manufacture under these conditions would have been restricted to only the summer months, which would have rendered the process impracticable. In the erection of the full-sized complete plant at Carnlough, however, the inventor was able to effect several modifications in the design of his furnace, with the result that it is now possible to use peat containing as much as 65 or 75 per cent of moisture. Seeing that raw peat contains approximately 87.5 per cent of moisture, the elimination of water down to the required limit of 70 per cent is an easy and inexpensive matter.

AERIAL CABLEWAY TWO MILES IN LENGTH CONNECTING PEAT BOG WITH PLANT.

The Carnlough plant has an immediate supply of peat in over 3,000 acres, the sole right to exploit which has been acquired for a period of forty years. The raw material available is sufficient to yield, upon a basis of five per cent of ammonium sulphate, from 130,000 to 150,000 tons of the fertilizer. The bog has been drained, and several miles of surface railroad laid down to convey the supplies from the various excavating sites to the terminal of the aerial ropeway, which transports the peat to the plant two miles distant and automatically dumps the material into the furnaces.

The plant in addition to the evaporation furnaces comprises the patent Woltereck scrubbers, alkaline and acid absorption towers, together with crystallizing and centrifugal apparatus. There is a battery of three 100-horse-power Babcock & Wilcox water-tube boilers with automatic stoking, air compressors, acid elevators, pumps, blowers, besides other special machinery required in the process, as well as an extensive laboratory.

VIEW OF PEAT BOG, SHOWING RAW MATERIAL CUT AND STACKED READY FOR TRANSPORTATION TO FURNACES.

AMMONIA SULPHATE FROM PEAT.

The peat upon being dumped into the furnaces is subjected to moist combustion by means of a blast of air charged with water vapor and maintained at a regulated temperature. The gases produced by this oxidation are collected and carried through ducts leading to various vessels. First the tarry products are arrested by being passed through the scrubber, the paraffine tars being deposited without any condensation and consequently without any loss of ammonia. The paraffine tar is subsequently drawn off from this scrubber, and subjected to distillation to remove the lighter oils.

Passing from the scrubber the gases continue their journey, and next have the acetic acid absorbed in the lime tower. The gaseous stream ascends the tower, and in so doing meets a continuously descending shower of hot milk of lime, with which the acetic acid and kindred products combine, thereby forming acetate of lime. The liquid after absorption flows downward into a tank, whence it is again elevated to the top of the tower by means of pumps, to descend once more, thereby becoming further charged with acetic acid, this cycle of operations being repeated until it contains the maximum of collected acetic acid. Finally this acetate solution is evaporated to dryness and distilled with hydrochloric acid to obtain concentrated acetic acid, or can be subjected to dry distillation in order to produce acetone.

From the acetic acid absorption tower, the gaseous products pass into lead-lined acid towers, which they again ascend. During their progress they are brought into intimate contact with a descending shower of weak hot sulphuric acid in a very fine state of subdivision. The gases are thus deprived of their ammonia content, which combining with the sulphuric acid form sulphate of ammonia. The ammonium sulphate solution is subjected to further treatment in order to neutralize the acid, whence it is drawn off to the crystallizing vats. Here is is sufficiently concentrated, allowed to cool, all supernatant impurities are removed and finally crystallized from the concentrated liquor, purified, and after centrifuging in order to remove any adhering liquor, is ready for shipment.

All difficulties concerning combustion have been overcome. In the model installation it was impossible to secure the equal distribution of the peat over the furnace, which resulted in irregular oxidation over the internal area of the latter. Likewise no difficulties concerning the ash clogging the bars are experienced. With the modifications effected in the Carnlough installation, complete efficiency and evenness in combustion are assured. The ammonium sulphate produced is in every way comparable with that secured as a by-product in coal-gas manufacture. Its fertilizing properties are equal. At first, owing to the color and slight odor of the peat product, its marketable value was about $1.25 per ton less than the ordinary commercial ammonium sulphate, but the color and odor have been removed, as well as the complete purification of the product assured, so that now it competes with the common fertilizer.

The cost of manufacture renders it sufficiently remunerative. The cost of the raw material at the furnaces varies according to the close proximity of the bog and the expense entailed in its transportation therefrom. With mechanical handling and an excavating plant, however, this approximates $1.04 per ton,

and the cost of manufacture represents $39 per ton, upon a basis of 5 per cent yield of ammonium sulphate from the peat. As, however, acetic acid and paraffine tars are secured, which represent a value of about $12.25 per ton, the net cost of ammonium sulphate is $27.50 per ton. Even should the cost of excavating the peat be double the foregoing, a sufficiently wide margin is available for profit, since the average market price is $60 per ton.

Dr. Woltereck estimates that the yield of sulphate of ammonia is 5 per cent, but practice has proved that it is much higher, an average of 7½ per cent having been maintained over a period of several months. Similarly, the yield of acetic acid and tar was computed to be 0.5 and 2.5 per cent respectively, but operations have shown that the yield of acetic acid is at least 1 per cent, while that of paraffine tars is practically 4.5 per cent. Even the ash is of value as a cheap manure, since it contains potassium salts, lime, and phosphoric acid.

The most salient feature of the process, apart from its direct production of a fertilizing agent, is the possibility of utilizing peat impregnated with 75 per cent of water, and obviating preliminary sun drying, which in temperate and humid countries is a distinct advantage; while the yield of at least 5 per cent of ammonium sulphate renders the process commercially feasible. The Carnlough plant is turning out the product night and day. The increasing requirements of agriculture insure a ready sale, the demand at present being far in excess of the supply; and though the marketable value of the fertilizer is entirely governed by these two conditions, an appreciable decrease in price will not materially affect the financial success of the enterprise.

THE MECHANISM OF IMMUNITY.

A PERSON attacked by a disease of microbial origin becomes immune to that disease for a longer or shorter period, and often for life. In some cases the immunity is transmitted to offspring. An infant whose mother has been vaccinated shortly before its birth is born immune and will not, for several months at least, react to vaccination.

The Latin author Lucian describes an African tribe which enjoyed an inherited immunity to snake venom and tested this immunity by allowing the newly born infants to be bitten by snakes. Dr. Calmette's experiments by immunizing animals to snake bite by means of snake venom show that if the bite thus inflicted did not prove fatal it would increase and make permanent the immunity already possessed by the child.

Certain diseases which were very fatal when they first appeared in Europe have become comparatively mild. This result is doubtless due in part to a relative immunity acquired by the race in consequence of repeated infection. The harmlessness of certain microbes may be explained in the same way. Even in health, we harbor in the mouth and intestine various microbes which are certainly pathogenic but whose virulence has become weakened. The mouths of many persons contain pneumococci which can kill, in twenty-four hours, mice into which they are injected.

In cholera epidemics persons not stricken by the disease may yet carry in their intestines virulent bacilli, and thus infect persons of less resistance.

Microbes live in the body as parasites and produce specific disease when the resistance of the organism is lessened by exhaustion, exposure, moral shock or other cause. If a guinea pig is inoculated with a pure culture of the bacillus of tetanus (lockjaw), the white corpuscles of the animal's blood quickly engulf the germs, but occupy several weeks in digesting them. Vincent has proved that if, during this period, the vitality of the phagocytes, or white corpuscles, and of the tissues is diminished by heat or other physical or chemical agency, the germs remain able to multiply and cause a fatal attack of tetanus. When the bacilli of tetanus are applied to a wound, they may likewise be destroyed if the normal process of phagocytosis is not checked. Open, bleeding wounds, which offer abundant opportunity for the accomplishment of phagocytosis in the blood plasma and the solution of the bacilli in the serum, are not often followed by tetanus. But in contused wounds, which do not permit free access of blood to the bacilli, the latter multiply and produce a toxin which permeates the body and gives rise to the characteristic symptoms of tetanus.

Hence it appears that the human organism possesses a certain degree of immunity to tetanus. The same statement applies to the majority of germ diseases. In all cases the dose of infection is a matter of importance and so is the resistance of the subject, that is to say, the degree of immunity acquired by the presence of germicides in the blood or by the ability to produce such substances with greater or less rapidity. If only very few germs are introduced they will be destroyed at once, before they can penetrate to any distance, by the bactericidal substances which exist normally in the organism, and thus the enemy will be stopped at the frontier. On the other hand, if the germs have invaded the body and multiplied, the organism is called upon to produce germicides in great quantity. This process of reaction is marked by fever and other symptoms of inflammation, and it terminates either with death or with recovery and more or less lasting immunity.

THE PEAT IS AUTOMATICALLY DUMPED IN THE FURNACE.

The mechanism of the acquirement of immunity has been revealed by very ingenious experiments. Organic substances introduced into the tissues are there destroyed by a sort of digestive process, and if the patient survives the disturbance thus caused he becomes immune to those particular substances. Sheep's blood injected into the peritoneum of a rabbit is absorbed and the blood of the rabbit acquires the power to dissolve and destroy sheep's blood, even outside of the body. This solvent power appears to be due to the presence of two distinct substances. One of these is the complementary substance, or alexine, which is found in all serum, including that of animals which have not been immunized, and which is destroyed by heating to 131 deg. F.; the other is a specific substance, called an anti-body, sensitizer or amboceptor. There are as many sensitizers as there are organic substances which make the organism immune to themselves.

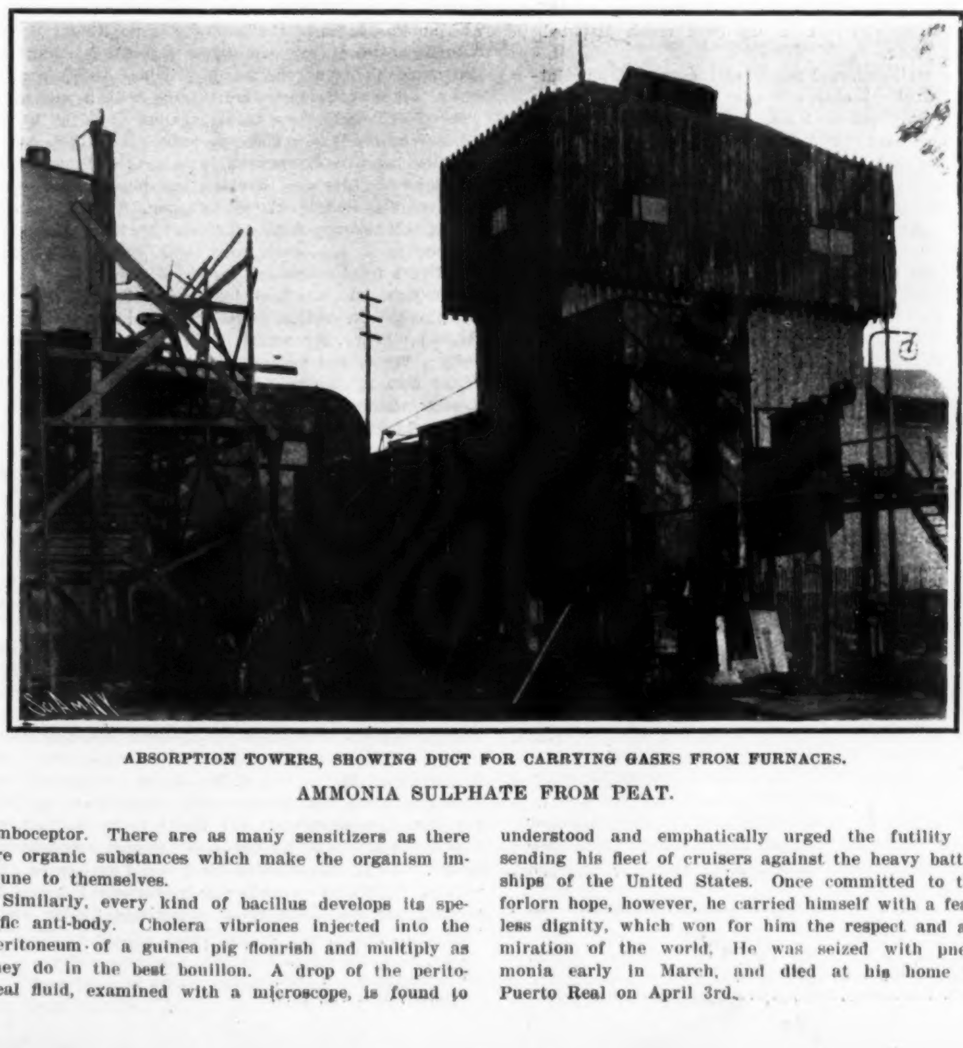
Similarly, every kind of bacillus develops its specific anti-body. Cholera vibriones injected into the peritoneum of a guinea pig flourish and multiply as they do in the best bouillon. A drop of the peritoneal fluid, examined with a microscope, is found to be swarming with active vibriones, exactly like those of a laboratory culture. If the bacilli are not very virulent or the dose is very small, the animal survives and becomes immune to cholera, as the result of the inoculation or a series of inoculations of gradually increasing strength. If the peritoneal fluid of the immune animal is examined a few minutes after a fresh inoculation, the injected bacilli are found diminished in number and collected in motionless clusters which show a tendency to melt and dissolve in the surrounding liquid. The same result is produced outside of the body. The cholera vibriones live and multiply in the serum of an animal which has not been inoculated, but agglutinate and dissolve in the serum of an immunized animal.

This phenomenon is general, although more or less clearly defined with different species of germs. The serum of a typhoid convalescent agglutinates typhoid bacilli. Agglutinization by immunized serum occurs also with pneumococci and, in certain conditions, with Koch's bacilli. This reaction is employed every day in the diagnosis of typhoid fever, and true typhoid, caused by the bacillus of Eberth, is thus distinguished from the "paratyphoid" conditions which have been recognized in recent years.

This process of bacteriolysis is entirely similar to the process of hemolysis described above. It does not take place if the serum is heated to 131 deg. F., but the addition of serum from a non-immunized animal restores the power of the heated serum by making possible the action of the sensitizer or anti-body, which is not destroyed unless the temperature is raised to 158 deg. F.

The anti-bodies have not been isolated and it has not been proved that the serum of immunized animals contains chemically definite substances of this character. I am inclined to believe that a sort of colloidal compound is formed, in which a substance which is the same in all serums analogous to alexine is combined with a substance derived from the bacillus. In other words, the various specific anti-bodies are analogous to the salts of the same acid with various bases. This simple hypothesis explains the ability of the organism to produce an immunized serum or a specific anti-body for each of the many bacterial and other poisons with which it may be inoculated, and accounts for the indeterminate number and rigorously specific characters of the anti-bodies.—Cosmos.

Sympathetic interest was aroused in this country by the announcement of the death of Admiral Cervera who, it will be remembered, commanded the Spanish fleet at the battle of Santiago. He was one of the ablest and most far-sighted of the Spanish admirals, and in the midst of much misapprehension as to the relative strength of the two navies, Cervera clearly understood and emphatically urged the futility of sending his fleet of cruisers against the heavy battleships of the United States. Once committed to the forlorn hope, however, he carried himself with a fearless dignity, which won for him the respect and admiration of the world. He was seized with pneumonia early in March, and died at his home in Puerto Real on April 3rd.



ABSORPTION TOWERS, SHOWING DUCT FOR CARRYING GASES FROM FURNACES.

AMMONIA SULPHATE FROM PEAT.

SOME ASTRONOMICAL CURIOSITIES.

CELESTIAL PARADOXES.

BY J. E. GORE, M.R.I.A.

There are many curious facts and observations connected with astronomy which are not usually mentioned in popular books on the subject. The following are some of these:

From experiments made in November, 1906, at Moscow, Prof. Ceraski found that the light of the sun's limb is only 31 to 38 times brighter than the illumination of the earth's atmosphere close to the limb. This is a very unexpected result; and considering the comparative faintness of the sun's corona during a total eclipse of the sun, it is not surprising that all attempts to photograph it without an eclipse have failed.[1]

The so-called blackness of sun-spots is merely relative. They are really very bright. The most brilliant light which can be produced artificially looks like a black spot when projected on the sun's disk.

M. Leo Brenner thinks that he has seen the dark side of the planet Mercury in the same way that the dark side of Venus has been seen by many observers. In the case of Mercury the "dark side" appeared *darker* than the background of the sky. Perhaps this be due to its being projected on the zodiacal light, or outer envelope of the sun.[2]

When Venus is at its greatest brilliancy and appears as a morning star about Christmas time (which occurred in 1887 and again in 1889), it has been mistaken by the public for a return of the "Star of Bethlehem." But whatever "the star of the magi" was it certainly was not Venus. It seems indeed absurd to suppose that the wise men of the East should have mistaken a familiar object like Venus for a strange apparition. There seems to be nothing whatever in the Bible to lead us to expect that the Star of Bethlehem will reappear. Mr. J. H. Stockwell has suggested[3] that the "Star of Bethlehem" may perhaps be explained by a conjunction of the planets Venus and Jupiter which occurred on May 8th, B. C. 6, about two years before the death of Herod. From this it would follow that the crucifixion took place on April 3rd, A. D. 33. But it seems very doubtful that the phenomenon recorded in the Bible refers to any conjunction of planets.

The crescent shape of Venus is said to have been seen with the naked eye by Theodore Parker in America when he was only twelve years old. Other observers have stated the same thing; but the possibility of such an observation has been much disputed in recent years.

The well-known French astronomer, Trouvelot—a most excellent observer—saw white spots on Venus similar to those on Mars. These were well seen and quite brilliant in July and August, 1876, and in February and November, 1877. The observations seem to show that these spots do not (unlike Mars) increase and decrease with the planet's seasons. These white spots had been previously noticed by former observers, including Bianchini, Derham, Gruithuisen, and La Hire; but these early observers do not seem to have considered them as snow caps, like those of Mars. Trouvelot was led by his own observations to conclude that the period of rotation of Venus is short, and the best result he obtained was 23 h. 49 m. 28 s. This does not differ much from the results previously found by De Vien, Fritsch, and Schröter.[4] A white spot near the planet's south pole was seen on several occasions by H. C. Russell in May and June, 1876.[5] Photographs of Venus taken on March 18th and April 29th, 1908, by M. Quénisset at the observatory of Juvissy, France, show a white polar spot. The spot was also seen at the same observatory by M. A. Benoit on May 20th, 1903.

The controversy on the period of rotation of Venus, or the length of its day, is a very curious one, and has not yet been decided. Many good observers assert confidently that it is short (about 24 hours), while others affirm with equal confidence that it is long (about 225 days, the period of the planet's revolution round the sun). Among the observers who favor the short period are D. Cassini (1667), J. Cassini (1730), Schröter (1788-93), Mädler (1836), De Vico (1840?), Trouvelot (1871-9), Flammarion, Leo Brenner, Stanley Williams, and J. M'Harg; and among those who support the long period are Bianchini (1727), Schiaparelli, Cerulli, Tacchini, Mascari, and Lowell. Some recent spectroscopic observations seem to favor the short period.

[1] Nature, April 11th, 1907.
[2] Nature, November 29th and December [illegible]th, 1894.
[3] Nature, December 22nd, 1892.
[4] Nature, September 15th, 1892.
[5] The Observatory, 1880, p. 574.

The "secondary light" of Venus, or the visibility of the dark side (when the planet is in the crescent phase) seems to have been first mentioned by Derham in his "Astro Theology," published in 1715. He speaks of the visibility of the dark part of the planet's disk "by the aid of a light of a somewhat dull and ruddy color." The date of Derham's observation is not given; but it seems to have been previous to the year 1714. The light seems to have been also seen by a friend of Derham. We next find observations by Christfried Kirch, assistant astronomer to the Berlin Academy of Sciences, on June 7th, 1721, and March 8th, 1726. These observations are found in his original papers, and were printed in the Astronomische Nachrichten, No. 1586. On the first date the telescopic image of the planet was "rather tremulous," but in 1726 he noticed that the dark part seemed to belong to a smaller circle than the illuminated portion of the disk. The same effect was also noted by Webb. A similar appearance is seen in the case of the crescent moon, and this has given rise to the old saying: "The old moon in the new moon's arms."

We next come in order of date to an observation made by Andrias Mayer, professor of mathematics at Greifswold in Prussia. The observation was made on October 20th, 1759, and the dark part of Venus was seen distinctly by Mayer. As the planet's altitude at the time was not more than 14 deg. above the horizon, and its apparent distance from the sun only 10 deg., the phenomenon, as Prof. Safarik has pointed out, must have had a most unusual intensity.

Sir William Herschel makes no mention of having ever seen the "secondary light" of Venus, although he noticed the extension of the horns beyond a semicircle.

In the spring and summer of the year 1793 Von Hahn, of Ramplin, in Mecklenburg, using excellent telescopes, made by Dolland and Herschel, saw the dark part of Venus on several occasions, and describes the light as gray verging upon brown.

Schröter, of Lilienthal, the famous observer of the moon, saw the horns of the crescent of Venus extended many degrees beyond the semi-circle on several occasions in 1784 and 1795, and the border of the dark part faintly lit up by a dusky gray light. On February 14th, 1806, at 7 P. M. he saw the whole of the dark part visible with an ash-colored light, and he was satisfied that there was no illusion. On January 24th of the same year (1806) Harding at Göttingen, using a reflector of 9 inches aperture and power 84, saw the dark side shining with a pale ash-colored light, and very visible against the dark background of the sky. The appearance was seen with various magnifying powers, and he thought there could be no illusion. In fact, the phenomenon was as evident as in the case of the moon. Harding again saw it on February 28th of the same year, the illumination being of a reddish gray color, like that of the moon in a total eclipse.

The light was also seen by Pastorff in 1822, and by Gruithuisen in 1825. Since 1824 observations were made by Berry, Browning, Guthrie, Langdon, Noble, Prince, Webb, and others. Webb saw it with powers of 90 and 212 on a 9.38-inch mirror and found it equally visible when the bright crescent was hidden by a field bar.[6] Capt. Noble's observation was rather unique. He found that the dark side was always distinctly and positively darker than the background upon which it is projected. The light was also seen by Lyman in America in 1867, and by Safarik at Prague. In 1871 the whole disk of Venus was seen by Prof. Winnecke.[7] On the other hand, Winnecke stated that he had only seen it twice in twenty-four years. The great observers Dawes and Mädler never saw it at all.[8]

Various attempts have been made to explain the visibility, at times, of the dark side of Venus. The following may be mentioned[9]: (1) Reflected earthlight analogous to the dark side of the crescent moon. This theory was advocated by Harding, Schröter, and others. But, although the earth is undoubtedly a bright object in the sky of Venus the explanation is evidently quite inadequate. (2) Phosphorescence of the planet's atmosphere. (3) Visibility by contrast, a hypothesis advanced by the great French astronomer Arago. (4) Illumination of the planet's surface by an aurora. This also seems rather inadequate, but would account for the light being sometimes visible and sometimes not. (5) Luminosity of the oceans—if there be any—on Venus. But this also seems inadequate. (6) A planetary surface glowing with intense heat. But this seems improbable; and (7) the *künstliches Feuer* (artificial fire) of Gruithuisen, a very fanciful hypothesis. Flammarion thinks that it may perhaps be explained by its projection on a somewhat lighter background, such as the zodiacal light, on an extended solar envelope.[10]

[6] Celestial Objects, Vol. I, p. 65 (Fifth Edition).
[7] Ast. Nach., No. 1,863.
[8] Nature, June 1st, 1876.
[9] Nature, June 8th, 1876.

It will be seen that none of these hypotheses is entirely satisfactory, and the phenomenon, if real, remains a sort of astronomical enigma. The fact that the light is visible on some occasions and not on others would render some of the explanations improbable or even inadmissible. But the condition of the earth's atmosphere at times might account for its invisibility on many occasions.

M. Hansky finds that the visibility of the light is greater during periods of maximum solar activity, that is at the maxima of sun-spots. This he explains by the theory of Arrhenius in which electrified ions emitted by the sun cause the phenomena of terrestrial magnetic storms and auroras. In the same way the dense atmosphere of Venus is rendered more phosphorescent and therefore more easily visible by the increased solar activity.[11] This seems a very plausible hypothesis.

There is a curious illusion with reference to the moon's apparent diameter referred to by Proctor.[12] If, when the moon is absent in the winter months, we ask a person whether the moon's diameter is greater or less than the distance between the stars δ and ϵ, and ϵ and ζ Orionis (the three well-known stars in the belt of Orion), the answer will probably be that the moon's apparent diameter is about equal to each of these distances. But in reality the apparent distance between δ and ϵ Orionis (or between ϵ and ζ, which is about the same) is more than double the moon's apparent diameter. This seems at first sight a startling statement; but its truth is, of course, beyond all doubt, and is not open to argument. Proctor points out that if a person estimates the moon as a foot in diameter, as its apparent diameter is about half a degree, this would imply that the observer estimates the circumference of the star sphere as about 720 feet (360 deg. × 2), and hence the radius (or the moon's distance from the earth) about 115 feet. But in reality all such estimates have no scientific (that is, accurate) meaning. Some of the ancients, such as Aristotle, Cicero, and Heraclitus seem to have estimated the moon's apparent diameter at a foot.[13] This shows that even great minds may make serious mistakes.

Chacornac found that the illumination of Saturn's disk is the reverse of that of Jupiter, the edges of Saturn being brighter than the center, while in the case of Jupiter, as that of the sun, the edges are fainter than the center. According to Mr. Denning, Saturn bears satisfactorily greater magnifying power than either Mars or Jupiter.

It was computed by M. Faye that the volume of the famous Donati's comet (1858) was about 500 times that of the sun! On the other hand, he calculated that its mass (or quantity of matter it contained) was only a fraction of the earth's mass. This shows how almost inconceivably tenuous the material forming the comet must have been—much more rarefied indeed than the most perfect vacuum which can be produced in an air pump! This tenuity is shown by the fact that stars were seen through the tail "as if the tail did not exist." A mist of a few hundred yards in thickness is sufficient to hide the stars from our view, while a thickness of thousands of miles of cometary matter does not suffice even to dim their brilliancy.

On November 29th, 1905, Sir David Gill observed a fireball with an apparent diameter equal to that of the moon, which remained visible for five minutes and then disappeared in a hazy sky. Observed from another place, Mr. Fuller found that the meteor was visible two hours later! Sir David Gill stated that he does not know of any similar phenomenon.[14]

During the night of July 21st-22nd, 1896, Mr. William Brooks, the well-known astronomer, and director of the Smith Observatory at Geneva (New York), saw a round dark body pass slowly across the moon's bright disk, the moon being nearly full at the time. The apparent diameter of the object was about

[10] Nature, October 17th, 1895.
[11] Nature, July 27th, 1905.
[12] Nature, March 3rd, 1870.
[13] Nature, March 31st, 1870, p. 557.
[14] Bulletin, Ast. So. de France, May, 1906.

one minute of arc, and the duration of the transit 3 or 4 seconds, the direction of motion being from east to west. On August 22nd of the same year, Mr. Guthman (an American observer) saw a meteor crossing the sun's disk, the transit lasting about 8 seconds.[15]

A meteor which appeared in Italy on July 7th, 1892, was shown by Prof. von Niessl to have an ascending path toward the latter end of its course! The length of its path was computed to be 683 miles. When first seen its height above the earth was about 42 miles, and when it disappeared its height had increased to about 98 miles, showing that its motion was directed upward![16]

In the case of the fall of meteoric stones, which occasionally occurs, it has sometimes been noticed that the sound caused by the explosion of the meteorite, on its passage through the air, is heard before the meteorite is seen to fall. This has been explained by the fact that owing to the resistance of the air to a body moving at first with a high velocity its speed is so reduced that it strikes the earth with a velocity less than that of sound. Hence the sound reaches the observer before the body strikes the ground.[17]

In Central Arizona there is a hill called Coon Butte, or Coon Mountain. This so-called "mountain" rises to a height of only 130 to 160 feet above the surrounding plain, and has on its top a crater of 530 to 560 feet deep, the bottom of the crater, which is dry, being thus 400 feet below the level of the surrounding country. This so-called "crater" is almost circular, and nearly three-quarters of a mile in diameter. It has been suggested that this "crater" was formed by the fall of an enormous iron meteorite, or small asteroid. The crater has been carefully examined by a geologist and a physicist. From the evidence and facts found, the geologist (Mr. Barringer) states that they do not leave in his mind a scintilla of doubt that this mountain and its crater were produced by the impact of a large meteorite or small asteroid. The physicist (Mr. Tilghmann) says that he is justified, under due reserve as to subsequently developed facts, in announcing that the formation at this locality is due to the impact of a meteor of enormous and unprecedented size. There are numerous masses of meteoric iron in the vicinity of the "crater." The so-called Canyon Diabolo meteorite was found in a canyon of that name, about 2½ miles from the Coon Mountain. The investigators estimate that the great meteoric fall took place not more than 5,000 years ago, perhaps much less. Cedar trees about 700 years old are now growing on the rim of the mountain. From the results of artillery experiments, Mr. Gilbert finds that a spherical projectile striking solid limestone with a velocity of 1,800 feet a second will penetrate to a depth of something less than two diameters, and from this Mr. L. Fletcher concludes that a meteor of large size would not be prevented by the earth's atmosphere from having a penetrative effect sufficient for the production of such a crater.

The Canyon Diabolo meteorite above referred to was found to contain diamonds—some black, others transparent. So some have said that the diamond is a gift from heaven, conveyed to earth in meteoric showers. But diamond-bearing meteorites would seem to be rather a freak of nature. It does not follow that all diamonds had their origin in meteoric stones. The mineral periodot is frequently found in meteoric stones, but it is also a constituent of terrestrial rocks.

With reference to the rising and setting of the stars, due to the earth's rotation on its axis, the late Sir George Airy, astronomer royal of England, once said to a schoolmaster, "I should like to know how far your pupils go into the first practical points, for which reading is scarcely necessary. Do they know that the stars rise and set? Very few people in England know it. I once had a correspondence with a literary man of the highest rank on a point of Greek astronomy, and found that he did not know it."[18]

On the 4th of March, 1796, the famous French astronomer, Lalande, observed on the meridian a star of small sixth magnitude, the exact position of which he determined. On the 15th of the same month he again observed the star, and the places found on these two nights refer to the numbers 16,292-3 of the reduced catalogue. In the observation of March 4th, he attached the curious remark, "Etoile singulière." (The observation of March 15th is without note.) This remark of Lalande has puzzled observers, who failed to find any peculiarity about the star. Indeed, the remark is a strange one for the observer of so many thousands of stars to attach, unless there was really something singular in the star's aspect at the time. On the evening of April 18th, 1887, the star was examined by the present writer, and the following is the record in his observing book: "Lalande's 'étoile singulière' (16,292-3) about half a magnitude less than η Cancri. With the binocular I see two streams of small stars branching out from it north proceeding [northwest] like the tails of a comet." This may, perhaps, have something to do with Lalande's curious remark.

[15] Nature, September 10th, 1896.
[16] Nature, June 9th, 1893.
[17] Journal, B.A.A., May 22nd, 1903.
[18] The Observatory, July, 1895, p. 290.

Burnham once saw a faint companion to Sirius of the sixteenth magnitude and measured its position. But he afterward found that it was not a real object but a reflection from Sirius (in the eyepiece). Such false images are called ghosts.

With reference to the well-known double (or rather quadruple) star ϵ Lyræ, near Vega, and supposed faint star near it, Burnham says: "From time to time various small stars in the vicinity have been mapped, and much time wasted in looking for and speculating about objects which only exist in the imagination of the observer." He thinks that many of these faint stars supposed to have been seen by various observers are merely ghosts produced by reflection.

It is a curious fact that the performance of a really good refracting telescope actually exceeds what theory would indicate, at least so far as double stars are concerned. For example, the famous double-star observer, Dawes, found that the distance between the components of a double star which can just be divided is found by dividing 4.56 sec. by the aperture in inches. Now theory gives 5.52 sec. divided by the aperture. The actual telescope—if a really good one—thus exceeds its theoretical requirements. The difference between theory and practice in this case seems to be due to the fact that in the "spurious" disk shown by a good telescope, the illumination at the edges of the star disk is very feeble, so that its full size is not seen except in case of a very bright star.

The star known as W Ursæ Majoris (the variability of which was discovered by Muller and Kempf in 1902), and which lies between the stars θ and υ of that constellation, has the marvelously short period of four hours (from maximum to maximum). Messrs. Jordan and Parkhurst find from photographic plates that the star varies from 7.24 to 8.17 magnitude. The light at maximum is therefore more than double the light at minimum. A sun which loses more than half its light and recovers it again in the short period of four hours is certainly a curious and wonderful object.

Dr. See, observing with the telescope of the Lowell Observatory, found that when the sky is clear, the moon absent, and the seeing perfect, the sky appeared in patches to be of a brownish color, and suggests that this color owes its existence to immense cosmical clouds, which are shining by excessively feeble light. Dr. See found that these brown patches seem to cluster in certain regions of the Milky Way.

Some curious and interesting phenomena are recorded in the old Chinese annals which go back to a great antiquity. In B. C. 687 a night is mentioned without clouds and without stars. This may perhaps refer to a total eclipse of the sun; but if so the eclipse is not mentioned in the Chinese list of eclipses. In the year 141 B. C. it is stated that the sun and moon appeared of a deep red color during five days, a phenomenon which caused great terror among the people. In 74 B. C. it is related that a star as large as the moon appeared, and was followed in its motion by several stars of ordinary size. This probably refers to an unusually large bolide or fire-ball. In 38 B. C. a fall of meteoric stones is recorded of the size of a walnut. In 88 A. D. another fall of stones is mentioned. In A. D. 321 sun-spots were visible to the naked eye.

There is a story of an eminent astronomer who had been on several eclipse expeditions, and yet was heard to remark that he had never seen an eclipse. "But your observations of several eclipses are on record," it was objected. "Certainly I have on several occasions made observations, but I have always been too busy to look at the eclipse." He was probably in a dark tent taking photographs, or using a spectroscope during the totality.—Knowledge and Scientific News.

SIMPLE SOLUTION OF EXPONENTIAL FORMULÆ.

A CORRESPONDENT sends us the following simple method, by which he solves the exponential formulæ frequently encountered in hydraulic and similar work. When, for instance, the formula includes a decimal fraction which was either to be raised to a decimal fractional power or to have a fractional root extracted, the operation by the methods usually given in books on logarithms is confusing to some, and the following method avoids addition or subtraction of ten to or from the characteristic, and is easily remembered.

For example, to obtain the value of an expression that is a decimal, and has a decimal exponent, make the decimal into a true *fraction*. Raise the numerator to the desired power, and the denominator to the same power. Subtract logarithm of denominator from logarithm of numerator, and the remainder is the logarithm of the required value.

The logarithm of a logarithm is used, which is added to the logarithm of the exponent. And the number corresponding to this logarithm is itself the logarithm of either numerator or denominator, as the case may be.

In a decimal root example, the reciprocal of the decimal exponent is found, and it always becomes greater than unity, so that the logarithm of this exponent will have a plus characteristic, and is therefore easily found.

$$0.455^{0.237} = \frac{455^{0.237}}{1000^{0.237}}$$

log 455 = 2.658011
log of (log 2.658011) = 0.424557
log 0.237 = $\bar{1}$.374748

Number corresponding to $\bar{1}$.799305 is 0.629948 = log of numerator.

log of 1000 = 3.000,000
log of (log) 3 = 0.477121
log of 0.237 = $\bar{1}$.374748

$\bar{1}$.851869

Number cor. to 0.711000 = log of denominator.

log of numerator = 0.629948
log of denominator = 0.711000

$\bar{1}$.918948

Number corresponding to = 0.82975 = $0.455^{0.237}$. Answer.

Then the reverse operation, to obtain the decimal root of a decimal fraction

$$\sqrt[0.237]{0.82975} = \sqrt[0.237]{\frac{82,975}{100,000}} = \frac{82,975^{\frac{1}{0.247}}}{100,000^{\frac{1}{0.237}}}$$

The exponent when reduced becomes a whole number,

log 1 — 0.000000
log 0.237 = $\bar{1}$.374748

0.625252

4.2194 = number corresponding, = new exponent.

$$\frac{82,975^{\frac{1}{0.237}}}{100,000^{\frac{1}{0.237}}} = \frac{82,975^{4.2194}}{100,000^{4.2194}}$$

First to find logarithm of numerator of this fraction.

log 82975 = 4.918947
log (of log) 4.918947 = 0.691873
log of exponent 4.2194 = 0.625251

1.317124

Number corresponding = 20.755072 = log of numerator.

To find logarithm of denominator:

log of 100,000 = 5.000000
log of (log 5.000,000) = 0.698970
log of exponent 4.2194 = 0.625251

1.324221

Number corresponding = 21.096990 = log of denominator.

log of numerator = 20.755072
log of denominator = 21.096990

$\bar{1}$.658082

Number corresponding = 0.455.

GERMAN DIATOMACEOUS EARTH.

INFUSORIAL or diatomaceous earth finds many practical applications, notably in the manufacture of dynamite, polishing soaps, soluble glass, gutta percha articles, and many other things. Germany has long been the principal producer of this earth and affords the best qualities. The principal deposits are in Hanover, where the kieselguhr occurs in beds among other alluvial deposits or in proximity with lignite seams. It generally forms a granular mass of gray, brownish, or pale green color; it has a dry feeling, absorbs water with avidity, is friable, and at ordinary temperatures resists chemical decomposition. It occurs in great quantities near Hützel, in the Lümberger Heide, and at Unterliess, in the same part of Hanover. It is also found at Vogelsberg, in Hesse, at Jastrobe, in Hungary, at Franzenbad, in Bohemia, and in Tuscany.

The valuable characteristics of the earth are its light weight, its absorptive power, and its non-conductivity of heat, which makes it one of the best insulating materials. It is mined in much the same way as brick clay, in open pits. It is then spread on planks or on the bare ground, in the sunshine, to dry. Artificial methods of drying do not seem to prevail. The earth should never be allowed to come in contact with flame, as it will calcine rapidly. There is no special necessity for drying kieselguhr beyond that point accomplished by the sun, and, although numerous artificial means have been tried, they have not come into general use. Dry-air ovens may be advantageous in wet seasons, but are not economical except with the very finest grades of earth, such as are used for dynamite.

As the earth comes from the ground, it contains 70 to 90 per cent of water; after drying in the sun, it still retains 15 to 25 per cent of moisture. During shipment, it must be carefully protected from moisture.—Engineering and Mining Journal.

REINFORCED CONCRETE CHIMNEYS.

A NEW USE FOR CONCRETE BLOCKS.

BY DR. ALFRED GRADENWITZ.

ENDEAVORS have been made from time to time, especially in the United States, to use reinforced concrete as a material for the construction of industrial chimneys. In spite of the undoubted economical advantages to be derived from the use of this material, none of the systems so far suggested has been employed on any very extensive scale.

The reason of this would seem to lie in the fact that builders have so far tried to use forms and scaffolding as employed for other kinds of concrete structures. This, combined with the expense of erecting and removing the scaffolding, more than offset the advantages of iron concrete.

A successful attempt to build iron-concrete chimneys without any forms or external scaffolding has been made by a Belgian engineer, Mr. M. Dumas of Brussels. The chimneys built on this novel system (like all other concrete chimneys) are made up of a foundation, a basement, and the shaft proper. While the first two parts, which are situated close to the surface of the ground, do not show any remarkable feature, the construction of the shaft, which is composed of a number of concrete blocks, 25 centimeters (9.84 inches) in height, is decidedly novel. The number of blocks obviously depends on the diameter of the chimney. Each block is provided at one of its ends with a grooved projection, so that when laid in place a continuous vertical rib is formed, into which is inserted a longitudinal armature extending throughout the height of the chimney and being moored both in the foundation and basement. The entire chimney is thus virtually a single monolith, whose pressure on the ground is calculated in the same manner as that of any foundation.

The blocks are molded either in the workshops or on the site; being reinforced with iron bars, they are well able to stand any rough handling during the transport and erection. In addition to the longitudinal armatures above mentioned, the upper part of each layer of blocks is formed with a transverse armature, which takes the shape of a reinforcing ring fitted into a groove.

The concrete blocks are mounted with remarkable rapidity; the workmen installed in the interior of the chimney set them in layers of about twelve each, after which concrete is applied on the rib 25 centimeters (9.84 inches) in height, and the joint for the next layer is completed. An important feature is that the vertical armatures are arranged outside on the chimney, so as to be always at a lower temperature than the chimney proper, which excludes any objectionable effect of a difference in expansion. In fact, iron concrete in principle is fireproof only until the temperature of disintegration is reached; and though the coefficients of expansion of steel and concrete are practically identical, the heat conduction in the two substances is different, and owing to the possibility of a difference in temperature between the two, the risk of disintegration would by no means be impossible.

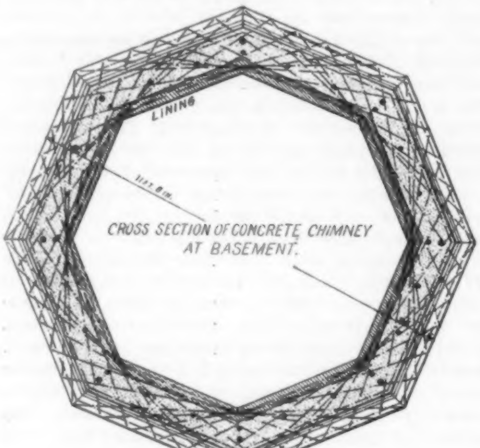
Another important point is the composition of the material, the various kinds of concrete being fireproof to a variable degree. The Belgian constructors accordingly used for their chimneys a special mixture of high safety. The use of a lining is recommended in the case of the presence of acid gases liable to attack the concrete or of temperature limits exceeding 800 deg. C. (1,696 deg. F.); the more so as this chimney system is especially adapted to such an arrangement.

The chimneys terminate on the top in a cap and a cast-iron ring, which communicates with the vertical armatures reaching down to the foundation. No special lightning arresters need therefore be provided. As the foundation is not exposed to any heavy loads, it need not be very substantial. This entails another saving.

Should the iron-concrete chimney for some reason or other (e. g., under the action of a cyclone or an earthquake) assume an inclined position, it would not be crushed like a chimney made of tiles, and could be straightened up at a trifling cost.

From the point of view of architecture, the chimneys, as shown by the accompanying illustrations, are of very pleasing appearance; and although more slender than tile chimneys, they are given a remarkably substantial aspect by their longitudinal armatures.

Sulphocarbon cement, for leather, rubber, etc., consists of 50 parts gutta percha, 120 parts of benzole, 80 parts sulphide of carbon, 20 parts of turpentine. Two such mixtures are prepared, of which one is scummed off and heated to boiling. The scum of the non-heated mixture is then mixed with the boiled mixture.



VIEW OF LONGITUDINAL AND VERTICAL REINFORCEMENT.

CHIMNEY OF CONCRETE BLOCKS 125 FEET HIGH. INTERIOR DIAMETER, 3 FEET 8 INCHES AT THE TOP.

CHIMNEYS BUILT OF IRON-CONCRETE.

THE ARTIFICIAL PROPAGATION OF MARINE SPONGES.

ALL the marine sponges of commerce come from a few small regions of the earth. Fine sponges are obtained chiefly from the eastern part of the Mediterranean, the cheaper and coarser sorts from the Mediterranean and the West Indies. Artificial propagation, the possibility of which has long been known, has been frequently essayed for the purpose of stocking coasts on which sponges do not naturally occur and restocking grounds which have been exhausted by rapacious and unscientific sponge fishing.

The first experiments were made on the Adriatic coast, near Trieste, more than forty years ago, and artificial cultivation of sponges has since been attempted in Florida waters, but in every case the attainment of practical and permanent success has been prevented by unforeseen difficulties. The sponge plantations were soon destroyed by natural or human agency, especially by the malice of rival sponge-fishers. Much yet remains to be learned concerning the conditions of successful propagation and culture of sponges and their diseases and animal enemies. Nor has sufficient attention been given to the financial part of the subject. In recent years sponge culture has been included in the extensive programme of the United States Fisheries Bureau. Laboratory experiments have been made, also, at Sfax, in southern Tunis, by the French government of the protectorate, and their results have been published by Dr. Allemand, the director of the station. These experiments were made, not with the highly prized bath sponge (*Euspongia officinalis*), but with the less valuable horse sponge (*Hippospongia equina*), which is found on the coast of Tunis and throughout the Mediterranean. It is easily recognized by its large size, roughly hemispherical shape, and large round pores. Its coarse and irregular texture makes it unsuited for toilet use, and it is employed exclusively in the stable and for various industrial purposes.

Artificial propagation of this species is most commonly effected by cutting a living sponge into pieces, each of which, in favorable conditions, regenerates a complete sponge. The process is very simple in principle, but its practical application is encumbered with difficulties. Although the sponge possesses abundant regenerative power, it cannot survive long separation from its natural habitat, especially in hot weather, so that the problem of transportation to its future home becomes very difficult.

Allemand found that the sponges died in four or five hours if the water in which they were placed was not changed, but that they could be kept alive ten hours or longer by renewing the water frequently. The experiments proved that regeneration can take place only in the sea, as captive sponges soon perish. The comparatively low temperature of 59 deg. F. was found the most favorable for fishing sponges for propagation.

The sponge having been secured in good condition, it is cut up into pieces about 1¼ inch high and ¾ inch wide, each containing a portion of the epidermis of the original sponge. Very sharp knives should be used, in order to avoid tearing or crushing the mass. The pieces of sponge are mounted on a frame which is at once immersed in the sea.

The form and material of the frame are important, and many of the earlier experiments failed owing to the employment of unsuitable frames. Allemand first used a sort of ladder, composed of two planks connected by bamboo rods, to which the fragments of sponge were fastened with pegs, but as the wood rapidly decayed in the sea water, perforated vessels of clay, terra cotta and brick were substituted.

In the immersion, as in the collection of the sponges, the temperature of the water is a matter of importance. Temperatures between 50 and 68 deg. F. gave very good results, while 77 deg. F. proved high enough to cause failure. After the healing of the cut surfaces, a process which usually occupies three months, higher temperatures are not specially injurious.

The most favorable months for the operation, in Tunis, appeared to be November, December, March, April and May, on account of the uniformity of temperature of the water. The sponge cuttings grow much less rapidly than young sponges developed from larvæ, occupying four or five years in attaining average market size. It was found that cuttings from small young sponges grew more rapidly and were more tenacious of life than cuttings from large old sponges. In order to obtain even this partial success the growing sponges must be shielded from light. The sponges planted in sunny waters grew slowly. The most rapid growth was obtained in the shade or even in almost total darkness. This result was to be expected, as sponges are found at depths to which very little light penetrates.

A second possible method of artificial propagation of sponges is afforded by sexual reproduction. This method was proposed in 1907 by the American biologist Monroe, in consequence of his success in propagating oysters by a similar method.

A minute study of the sexual reproduction of sponges, especially the horse sponge, has been made in Tunis. The production of eggs, which appear as white pellets in the sponge tissues, commences in October and continues until the end of January. The eggs are not apparently produced every year, for Allemand found them in only about two-thirds of the sponges examined. The larvæ make their appearance in April, May or June, according to the severity of the winter. The connection between the larvæ and the white pellets is proved by the observation that larvæ emerge only from sponges that contain pellets. The

larvæ produced by a single sponge may number several thousand. After a brief free-swimming life the larvæ attach themselves to the sea bottom and rapidly develop into sponges. The sponge fishers of Sfax assert that the horse sponge attains marketable size in one year, but two years is a more probable estimate.

The larvæ of the horse sponge are free-swimming, egg-shaped creatures of light yellow or gray color. They are very sensitive to external influences and avoid both bright light and total darkness. When placed in sunlight in a glass vessel they immediately take refuge in the darkest part of the vessel. They are also greatly affected by the temperature of the water. If this is higher than 64 deg. F. their movement becomes slower, their sensitiveness to light is diminished and they become flattened and at last fall to the bottom. They are quickly killed by temperatures above 77 deg. F. Low temperatures are equally unfavorable to the larvæ, which become rigid at 50 deg. F. and begin to die at 46 deg. F. They flourish best between 57 and 63 deg. F. The temperature of the water also governs the emergence of the larvæ, which appear most abundantly in the latter part of May. The larvæ are also very sensitive to the salinity of the water. They require a good deal of air. Immediately after their emergence they rise to the surface of the water where, in the laboratory experiments, they remain five days before they sink and become sessile. The length of their free-swimming life in the ocean is not known.

In captivity the larvæ are far more tenacious of life than the adult sponges, living forty-eight hours in the same water and several days in water that is frequently changed.

The propagation of sponges by eggs would be effected as follows: A few months before the larvæ appear, old sponges, either entire or in pieces, would be placed in frames or vessels such as have been described above and sunk in the sea in favorable locations. In due time the larvæ would emerge, attach themselves to the sea bottom and form a new plantation of sponges. No practical experiments with this method appear to have been made.

The artificial propagation of sponges is yet in the initial, tentative stage, but there is reason to believe that successful methods will in time be developed and that the supply of this valuable commodity will be increased by artificial plantations.—Prometheus.

A NEW ELECTROLYZER.

AN INEXPENSIVE DECOMPOSER OF WATER.

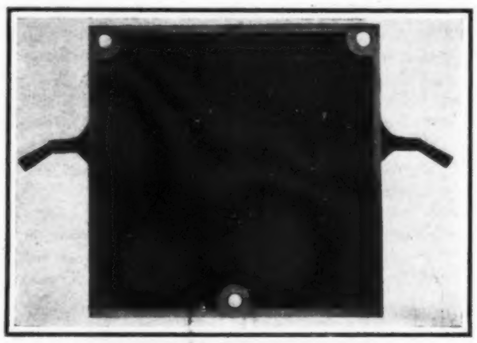
BY OUR PARIS CORRESPONDENT.

It is only since the use of large quantities of electricity at small cost that the electric decomposition of water has been commercially utilized. It can now be employed for the preparation of oxygen and hydrogen, which are the most important gases used industrially. At present the decomposition of water is carried out by the current in metallic vessels which are provided with iron electrodes, using as an electrolyte an alkaline solution. The apparatus employed up to this time have a great disadvantage lying in the fact that they occupy a large space. Besides, they require a great number of elementary cells which are connected in series to form the battery, and this gives rise to numerous connections, insulation, and gas-piping which are likely to get out of order and thus cause interruptions in the service of the plant.

A new design of electrolyzer known as the Oerlikon-Schmidt type has been brought out in Switzerland and patented in different countries. It appears to realize many advantages over the former apparatus, as will be noticed in the present description of the same, as it needs but a small amount of room and is quite simple in construction, giving a very regular working. It also needs but little attention. This type of apparatus is designed to furnish oxygen and hydrogen at a relatively high pressure such as has not been heretofore obtained.

The apparatus is made in different capacities, using a high or a low current, and it is made up of the elementary parts or electrode plates which will be noticed in our engraving. Such plates are of cast iron and have a border of about one inch width all around the plate, while the rest of the surface is sunken and is provided with a series of vertical projecting webs which are flush with the surface of the border. The plates are separated from each other by a diaphragm composed of pure asbestos tissue, and are provided with a rubber gasket corresponding to the border of the plate, this making the series watertight. The free space between the two plates and the diaphragm when the whole is pressed together constitutes an elementary cell. A greater or less number of cells is employed for the battery according to the tension of the current which is available for the purpose. The plates are mounted on a frame and are pressed together by means of a screw and hand-wheel, and the whole series thus has the appearance of a filter press, as will be observed in the view of the complete apparatus. The plates have two holes placed in the upper corners and a third hole in the middle of the lower border. Each surface of the plate is connected with one of the upper holes by means of a narrow groove, so that the oxygen which comes off from the front side of the plate can only escape by the right-hand hole, while the hydrogen produced on the rear side of the same plate can only find an outlet by the left-hand hole. When the plates are all pressed together, the series of holes makes a continuous tubular passage through the series of plates from end to end, and the oxygen escapes by one of the passages and the hydrogen by the other. These two openings are connected to a separator, an apparatus in which the gases are each separated from the liquid which may be brought over. In like manner the set of holes in the lower edge of the plates makes up a canal which serves for introducing the electrolytic liquid into the apparatus and the liquid is thus sent into the spaces between the plates.

Owing to the formation of the gases, there is a strong and continuous circulation of liquid in the apparatus, and this is an important point for securing the proper working of the electrolyzer. The liquid consists of a 10 per cent solution of pure carbonate of potash in distilled water, and it is quite necessary to use water having a great degree of purity and especially free from chlorine. Under the usual conditions of working, the gas is collected from the apparatus at



ELECTRODE PLATES OF THE NEW ELECTROLYZER.

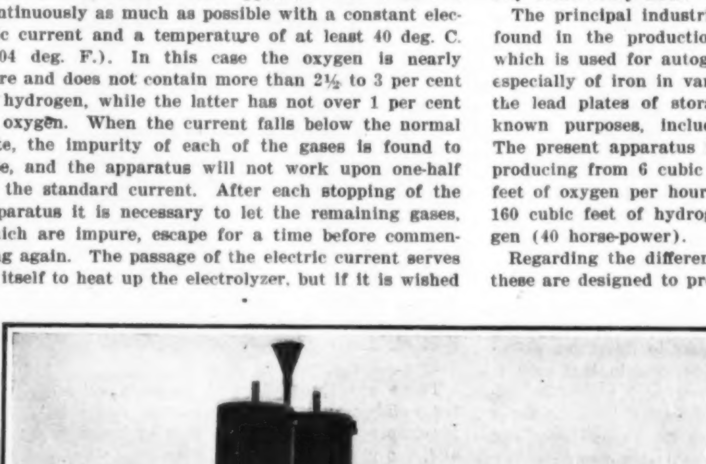
a pressure corresponding to a column of water of 8.3 feet in height. A reinforced construction of the electrolyzer will allow of obtaining for exceptional cases a pressure of gas corresponding to a water column of 83 feet (2.5 atmospheres). In order to obtain the gases in a pure state the apparatus should be run continuously as much as possible with a constant electric current and a temperature of at least 40 deg. C. (104 deg. F.). In this case the oxygen is nearly pure and does not contain more than 2½ to 3 per cent of hydrogen, while the latter has not over 1 per cent of oxygen. When the current falls below the normal rate, the impurity of each of the gases is found to rise, and the apparatus will not work upon one-half of the standard current. After each stopping of the apparatus it is necessary to let the remaining gases, which are impure, escape for a time before commencing again. The passage of the electric current serves in itself to heat up the electrolyzer, but if it is wished to gain time, the liquid can be heated up by steam beforehand.

In order to check up the purity of the gases while the apparatus is working, a small device is used which consists of two vertical glass tubes mounted side by side, partly full of water, and resembling water-gage tubes. By a smaller tube at the bottom, the hydrogen enters the large tube and escapes at the top of the latter by an orifice which gives a small outlet. The second tube allows the escape of the oxygen by a second nozzle and the two nozzles are turned facing each other and close together. The gas mixture which is thus formed between the nozzles is lighted, and it burns with a small flame as long as the gases are pure.

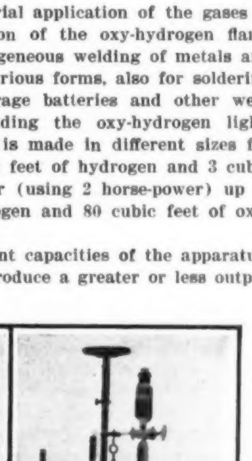
If there should be a mixture formed in the piping of the electrolyzer, the flame penetrates into the tube and the resulting noise shows that the mixture has become explosive. The water column in the two tubes serves to prevent the gas explosions from penetrating into the piping below. In the large plants of this kind it is necessary to further check up the purity of the gases by analysis, and the gas analyzer represented here is used for this purpose, being based on the absorption of oxygen by ammoniacal oxide of copper. Such analysis is carried out from time to time in order to assure a regular working of the plant. This is especially true where the gases are to be compressed in steel cylinders, when an analysis is generally made every hour.

The principal industrial application of the gases is found in the production of the oxy-hydrogen flame which is used for autogeneous welding of metals and especially of iron in various forms, also for soldering the lead plates of storage batteries and other well-known purposes, including the oxy-hydrogen light. The present apparatus is made in different sizes for producing from 6 cubic feet of hydrogen and 3 cubic feet of oxygen per hour (using 2 horse-power) up to 160 cubic feet of hydrogen and 80 cubic feet of oxygen (40 horse-power).

Regarding the different capacities of the apparatus, these are designed to produce a greater or less output



VIEW OF A LARGE SIZE NEW ELECTROLYZER.



THE GAS ANALYZER.

of gas according to the requirements of use, and they use a high or low current. Thus in the case of the 2-horse-power size, it uses a current of 20 amperes at 65 volts (1.3 kilowatts) and is made up of 28 chambers. It will produce 6.3 cubic feet of hydrogen and 3.15 cubic feet of oxygen per hour and requires 10 gallons of liquid to run it. The largest size of apparatus, which is made as a standard type, works upon 125 amperes current at 220 volts (27.5 kilowatts) and is provided with 96 chambers. It delivers 160 cubic feet of hydrogen and 80 cubic feet of oxygen at the normal rate of working. It is found that it is not practicable to use tensions which exceed 250 volts. This can be used with a special type of apparatus which has 109 chambers. As to the amount of energy which is taken by the present form of electrolyzer, we require about 6 kilowatts to produce in one hour at a temperature of 40 deg. C. (104 deg. F.) 1 cubic meter (35.3 cubic feet) of hydrogen and half this amount of oxygen. We may diminish the amount of energy somewhat by raising the temperature of the liquid, but this should not exceed 60 or 70 deg. C. (140 or 158 deg. F.).

The electromotive force to which corresponds the production of the above-indicated quantities of gas is (in the cold) 2.7 volts per chamber or electrolytic cell, and at 60 deg. C. (140 deg. F.) it is 2.3 volts per chamber, making an average of 2.4 volts per chamber to serve as the base for estimating the number of chambers which an electrolyzer should possess in order to work upon a given voltage. While the development of gas has not yet commenced, that is, when there is no tension of polarization, the internal electric resistance of the apparatus is very low. When the apparatus is started up, the value of the current would therefore rise much too high on account of this low resistance. To remedy this drawback a set of resistance coils is used which is placed in the circuit upon starting up, and this serves to reduce the current to its normal value. When the apparatus is fully working, the resistance is removed.

An important part of the question of electrolysis of water is the cost of producing the gas, and this naturally depends upon the price of current in any given locality. It is required about 12 kilowatt-hours to produce 1 cubic meter (35.3 cubic feet) of oxygen and 2 cubic meters (70.6 cubic feet) of hydrogen. Owing to the small first cost of the plant, the expense depends almost directly upon the price of current, seeing that the expenses and interest on the capital are almost negligible with relation to the price of the quantity of gas which is produced yearly. The price of current per kilowatt-hour varies on the Continent from 0.04 to 0.30 franc ($0.008 to $0.06), and the production of one cubic meter (35.3 cubic feet) of oxygen per hour will thus cost from 0.48 to 3.60 francs ($0.10 to $0.72). If we compare with this the current price of oxygen compressed in steel cylinders at 200 atmospheres pressure, which costs about 3.50 francs per cubic meter ($0.70) according to the above figures, it will be seen that the present method results in a considerable saving.

Besides the uses which we mentioned above for the oxy-hydrogen flame, each of the gases alone has a number of different applications. Oxygen alone finds many uses in the chemical industry which will be remembered, also in metallurgical work in the production and refining of steel, and also in the pure state in laboratories and in medicine. Hydrogen is employed for balloon work and in incandescent gas lighting, besides being used for its reducing properties in incandescent lamp manufacture.

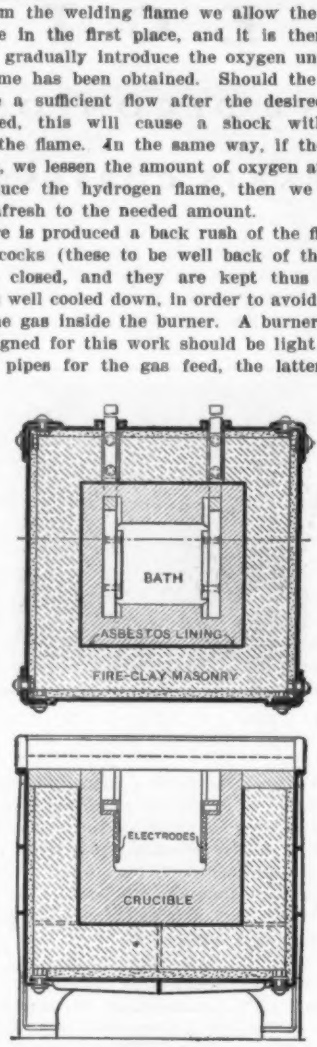
The welding of metal or what is known as autogeneous welding by means of the oxy-hydrogen flame has now assumed a great importance in the metal-working industries and continues to find more extensive applications. It will be *apropos* in this connection to bring out the conditions which should be fulfilled in order to obtain a good welded joint for sheet iron and plate iron. Owing to its intensity and its reducing properties, the oxy-hydrogen flame is specially adapted for autogeneous welding of thin and medium sheet iron. However, the most recent practice shows us that in order to obtain a good weld which has the required strength, the following points must be observed. First, the oxy-hydrogen flame should be of a reducing and not an oxidizing nature; second, the speed of the gas delivery should be just sufficient so that the flame is not blown; third, the size of the flame should correspond to the size of the pieces to be welded.

The flame will have reducing properties if it results from the mixture of 3 volumes of hydrogen for 1 of oxygen. We recognize in practice the reducing flame by means of its color, which is rather a violet than a reddish hue, while the oxidizing flame has a bluish tint. The reducing flame gives to the welded portion a brilliant metallic luster, while the oxidizing flame produces a great disengagement of gas which seems to come from the combustion of the particles of dissolved carbon. With the reducing flame we obtain, after cooling, a weld of good form and strength which can be easily worked by the file, while the oxidizing flame gives a brittle weld which is often full of blow-holes.

The speed of the gas feed should be chosen so that the flame is only very slightly blown in order to prevent the metallic particles from being driven off. This speed should, however, not be too low, so as to avoid a back-rush of the flame in the burner. In short, the speed of the gas mixture coming out of the burner should be slightly greater than the speed of propagation of the flame which is seen at the time the gas is lighted and which has a back rush in the opposite direction from the former. The hottest point of a well-regulated flame, that is, the point which is to be directed upon the piece to be welded, is at a distance of 0.2 to 0.4 inch from the end of the burner. We should not use too large a flame, so as to avoid melting the sheet iron, but on the other hand if it is too small, the welded joint is of a superficial and insufficient character.

To form the welding flame we allow the hydrogen to escape in the first place, and it is then lighted; then we gradually introduce the oxygen until the desired flame has been obtained. Should the hydrogen not have a sufficient flow after the desired mixture is secured, this will cause a shock with a back rush of the flame. In the same way, if the flame is too large, we lessen the amount of oxygen at first and then reduce the hydrogen flame, then we introduce oxygen afresh to the needed amount.

If there is produced a back rush of the flame, both the gas cocks (these to be well back of the burner) must be closed, and they are kept thus until the burner is well cooled down, in order to avoid the burning of the gas inside the burner. A burner which is well designed for this work should be light and have separate pipes for the gas feed, the latter to have



ARRANGEMENT OF THE CRUCIBLE AND ELECTRODES FOR ELECTRICALLY HEATED HARDENING BATHS.

conical points so as to give the greatest speed. The end of the burner should be bent about at a right angle. In order to put out the flame, the inverse of the above operation is carried out; that is to say, we shut off first the supply of oxygen and then the hydrogen.

There are three different methods generally used for welding sheet iron. First, the plates have been previously provided with a thin upturned edge; second, the plates are brought near each other and have a piece of iron wire placed in the interval, this wire being then melted; third, the plates are welded end to end. The operation is carried out by giving a to-and-fro movement of the flame for the purpose of melting the edges.

The first method uses the least amount of gas, as the flame is in contact with a relatively small surface, and there is not much heat lost by conduction. As to the second method, it consists in the melting of the wire placed between the edges of the plates, and as to strength of the joint it seems to give the best results in practice. The method of welding the plates end to end takes a greater quantity of gas and in general it only gives good results when the front and rear parts are treated one after the other. In order to use the first of these methods for large surfaces to be welded in the same piece, such as the longitudinal welding of a cylinder, it is required to connect the two edges by means of superficial joints made by the melting of a wire, such joints to be spaced about 4 inches apart. This method avoids the coming apart of the joint during the work.

ELECTRICALLY HEATED HARDENING BATHS.

In an article in Page's Weekly, the method of hardening small cutting tools adopted by the firm of Ludwig Loewe & Company, in their Berlin works, is referred to. The hardening process is carried on by means of electrically heated barium salt baths, the arrangement of the crucible and the electrodes being as shown in the accompanying engraving. By means of this process, it has been possible to harden large milling cutters in about half an hour, including the time for pre-heating, which takes the greatest part of the time. To bring the cutters up to a temperature of 750 deg. F. constitutes this pre-heating. After that, it takes only about a minute to bring an average-sized cutter to 1,400 or 1,500 deg. F., and then another minute to bring it up to about 2,370 deg. F., which is, by this firm, considered the right hardening temperature. The time stated above refers to average-sized and heavy milling cutters, whereas it takes only from 6 to 10 minutes to bring a small milling cutter to the right temperature in the electrically heated salt bath.

The advantage of electrically heated salt baths is stated as being the total absence of any scale on the tool thus hardened, and that the tools are not distorted in the hardening process. The bright appearance is retained by the hardened tool, so that it is sometimes difficult to tell from the appearance whether a tool has been hardened or not.

In regard to cooling the cutters, the firm of Ludwig Loewe has found that when high-speed steel tools are cooled in an air blast, any moisture coming in contact with the hot tool has a tendency to crack it, so that it becomes necessary to dry the air before it enters into the nozzles. It has also been found that it is absolutely impossible to cool a cutter which has a very heavy body and fine teeth in the air blast, as the heat from the central portion is not extracted fast enough, and therefore does not permit a sufficiently rapid cooling of the teeth to insure proper hardening. For this reason, the firm has adopted a method of cooling the cutters from the hardening heat of 2,370 deg. F. to a temperature of about 1,100 deg. F. by quenching in an electrically heated salt bath. After having been cooled to about 1,100 deg. F. in the bath the cutters are allowed to cool down slowly in the air, and the whole process has the advantage of being cheap and reliable, as well as effecting a considerable saving in time.

It must, however, be understood that electrically heated barium salt baths are advantageous to use only when a large quantity of tools is to be hardened, because this method will otherwise prove expensive. It has also been remarked that the electrically heated bath is more advantageous for heavy than for small tools, but it is not clear why the process should be thus limited to the former class of tools.

LOSS OF HEAT IN WATER-GAS GENERATORS.

Loss of heat in water-gas generators may be classified as follows: 1. Heat carried away by the gas. 2. Heat absorbed in dissociation of fuel. 3. Heat lost by radiation. 4. Heat carried off by solid residues. 5. Loss due to carbon dioxide in the gas. 6. Loss due to water in the gas.

1. A great deal of heat is carried off by the escaping gas. The following calculation relating to a coke furnace gives an idea of this quantity. Each pound of coke produced 6.8 pounds of gas. The temperature of the chimney being 550 deg. F., the loss of heat is $6.8 \times 550 \times 0.25 = 935$ English heat units (0.25 is the specific heat of the gas).

2. The loss by dissociation is small, and has never been accurately determined.

3. The loss by radiation is very great. It has not been determined exactly. It may be diminished by employing the radiated heat to warm the feed water.

4. The heat carried off by solid residues is comparatively small in ordinary generators, and still smaller in generators with water circulation at the bottom, as some of this heat is utilized in heating the water.

5. Most generators produce large quantities of carbon dioxide. This production is due to the fact that some of the fuel has not been heated to a sufficiently high temperature. Such a generator is very inefficient. The quantity of carbon dioxide should be reduced to a minimum.

6. An excess of water vapor passing over the coke will remain in the gas. Owing to the high specific heat of water vapor, the quantity of heat thus lost is very great. The total quantity of heat lost in all these ways may be 20 per cent of the heat produced. It should not exceed this proportion. The normal composition of the gas should be:

	Per cent
Hydrogen	4
Carbon monoxide from steam	4
Carbon monoxide from air	32
Nitrogen	60

ELECTROLYTIC LEAD COMPOUNDS.*

A NEW ELECTRO-CHEMICAL METHOD.

BY CARL DUVIVIER.

COMPOUNDS of lead are of considerable importance in the arts, more especially for the manufacture of paints and colors. The principal commercial products are white lead (lead carbonate) and red lead or minium (lead tetroxide); further, massicot or litharge (lead monoxide), lead chromate (chrome yellow), lead oxychloride (Cassel yellow), lead antimoniate (Naples yellow), lead peroxide, and various lead salts, such as the acetate and the nitrate.

Of all these compounds, only white lead has hitherto been prepared on a commercial scale by electrolytic processes. A large number of patents have been issued for such methods. It is, however, not definitely settled whether the products obtained in this way quite equal in covering power those prepared by the old processes. Three of the published processes were examined by the writer, and a brief description of these may here be given, before entering into a description of his own work.

In the direct process invented by T. D. Battome de Hoosick of New York, the electrolyte is a solution of 100 parts of ammonium nitrate and 100 parts of sodium nitrate in 1,000 parts of water. The anode is formed of sheet lead, the cathode is similar, or may be of sheet iron. Current density at anode, 1.4 ampere per square decimeter; at the cathode, any suitable current density. A stream of carbon dioxide is passed through the bath while electrolysis is in progress. At the anode nitric acid is formed, which attacks the lead, producing lead nitrate. This, in presence of an excess of water, and of ammonium and sodium hydroxides formed at the cathode, is hydrolyzed, giving lead hydroxide and regenerating the alkali nitrates. The lead hydroxide combines with the carbon dioxide continuously passed into the bath, thus giving lead carbonate or white lead. Barring a slight loss of ammonia, the electrolyte remains unchanged, since the only materials withdrawn from the process are lead and carbon dioxide, both of which are continually replaced as they are consumed.

In the Luckow process the electrolyte has the composition: Water, 1,000; sodium chlorate, 12; sodium carbonate, 3. Anode and cathode are lead plates. The current density at each is 0.5 ampere per square decimeter. Carbon dioxide is continuously blown into the bath through a narrow orifice, to avoid agitation.

At the anode soluble lead chlorate is formed, and immediately decomposed by the carbon dioxide, which precipitates lead carbonate and regenerates sodium chlorate. At the cathode sodium hydroxide is formed, and converted into sodium carbonate by the carbon dioxide blown into the bath. The process is thus continuous, the bath remaining unchanged in composition. This process is in use on a technical scale.

The process of A. B. Brown takes place in four stages:

1. A solution of sodium nitrate is decomposed by electrolysis in a cell divided into two compartments by a porous partition. The anode product is nitric acid, at the cathode sodium hydroxide is formed.

2. The nitric acid formed at the anode attacks the same, giving lead nitrate.

3. By means of the sodium hydroxide formed at the cathode, lead hydroxide is now precipitated from the solution of lead nitrate produced at the anode.

4. The lead hydroxide is converted into carbonate by treatment with carbon dioxide.

Quite generally it may be said that if we electrolyze a bath of salts of an acid whose lead salt is soluble, such as the nitrate, chlorate, etc., using lead electrodes, the anode dissolves and at the same time there is formed lead hydroxide, which is readily transformed into lead carbonate. We now pass on to a brief description of the processes worked out by the author.

LEAD CHROMATE (CHROME YELLOW).

The electrolyte consists of: Water, 1,000 parts; sodium or potassium nitrate, 100 parts.

The anode and cathode are of sheet lead. Current density at anode 1 to 2 amperes per square decimeter. At cathode the minimum practicable.

The current is passed until white flakes begin to appear. A cold saturated solution of sodium bichromate is then added drop by drop at such rate as to keep the solution a light yellow color.

If the temperature is not below 25 deg. C., the lead chromate rapidly settles to the bottom. The color of the product may be modified to a more or less deep orange by working at a higher temperature. At boiling heat a fine red basic chromate is obtained.

OXIDES OF LEAD.

By electrolyzing a solution containing a high percentage of caustic alkali, oxides and hydroxides of lead may be obtained.

The course of the process is as follows: We noted above that on electrolyzing a solution of an alkali salt of an acid whose lead salt is soluble, lead hydroxide is formed at the anode. If there is present an excess of caustic alkali, the lead hydroxide as it forms is dissolved in the alkali, forming alkali plumbite:

$$Pb(OH)_2 + KOH = PbOHOK + H_2O.$$

The oxygen formed at the anode converts the plumbite into plumbate:

$$PbOHOK + KOH + O = PbO(OK)_2 + H_2O$$

and the plumbate is finally peroxidized:

$$PbO(OK)_2 + O = PbO_2(OK)_2.$$

These products finally reach a concentration at which they are decomposed by the water, and converted into hydroxides, caustic potash being at the same time regenerated. The anode, which up to this point had remained bright, now becomes covered with lead peroxide, and liberates oxygen. If at this stage the solution is boiled, the above-mentioned hydroxides are decomposed, leaving as their dehydration products the corresponding oxides.

If we treat a hot solution of potassium plumbite, instead of hydroxide of lead, red lead (minium) Pb_3O_4 is formed, and drops off the anode, which is coated with lead peroxide. The reaction is probably:

$$2\ PbOHOK + PbO_2 = Pb_3O_4 + 2\ KOH.$$

The solution thus becomes reduced in its content of lead, and ultimately a state is reached when the lead peroxide no longer combines with the plumbite, and remains attached to the anode. Oxygen is then liberated just as in a charged electric accumulator.

In addition to the reaction given above, the following changes also go on in the bath:

1. Decomposition of the water, with liberation of oxygen at the anode and hydrogen at the cathode.

2. Decomposition of the caustic alkali, leading, by secondary reaction, to the formation of the same products as (1).

3. Decomposition of the alkali salt (nitrate) with formation of lead hydroxide at the anode and hydrogen at the cathode.

4. Decomposition of the plumbite itself, the lead passing to the cathode.

The net result is that hydrogen and lead are carried to the cathode, thus increasing the rate at which the lead content of the solution falls off.

The mode of procedure is as follows: The electrolyte may be prepared by either of two methods:

A solution may be prepared of: Distilled water, 500 parts; caustic potash, 200 parts; potassium nitrate, 25 parts. It should be noted that caustic soda cannot be used in place of the potash as sodium plumbite is but slightly soluble.

The cell consists of an outer pot of one liter capacity and an inner porous pot. Both are charged with the same solution. The anode is a lead sheet encircling the porous pot. The cathode is a piece of sheet lead or sheet iron wound in a spiral. A current of 0.9 ampere, giving a current density of 0.36 ampere per square decimeter is used. This is continued until eight to ten ampere hours have been passed through the cell, when the solution is ready for use.

The same result may be obtained more quickly by saturating at 40 to 50 deg. C. a solution of caustic potash (200) in water (100) with a cold saturated solution of lead nitrate. As soon as only a very slight precipitate remains after prolonged shaking, the solution is ready for use.

The solution obtained by either of these methods may be further treated either in the cold or near boiling heat.

For the cold treatment the current density at the anode should be about 0.4 to 2 amperes per square decimeter. At the cathode it may have any suitable value. Both electrodes are made of sheet lead, and the cathode is placed in a porous pot. As soon as oxygen begins to be liberated the current must be stopped. The electrodes and the porous pot are taken out, and the liquid is boiled, stirring continually. During this heating the yellowish precipitate formed in the first stage of the operation turns brown and finally brick-red. It consists of minium (red lead) of somewhat variable tint. It is allowed to settle, decanted, and washed by decantation and upon filter paper.

The alternative method is to work at 95 to 100 deg. C. with a current density of 24 amperes per square decimeter at the anode, and any suitable current density at the cathode. The anode must be well cleaned, and must not be introduced until the bath has reached the proper temperature. On passage of the current the anode blackens, and there is a strong evolution of oxygen. A red cloud is seen to proceed from the anode, and quickly to settle to the bottom. Very soon it becomes necessary to stop the operation owing to the violent bumping of the solution. The cathode becomes covered with a shining crystalline deposit of lead. The electrodes are now taken out, the liquid is allowed to cool, and the product is washed as before.

The electrolyte by this time contains only a small percentage of lead. It may be regenerated as follows: The solution decanted off from the precipitate is allowed to cool. The porous pot is washed, and the anode is cleaned with hot dilute nitric acid to which a small quantity of alkali nitrite (or a little sugar) has been added. This rapidly dissolves off the peroxide of lead adhering to the anode. The apparatus is then reassembled and the operation repeated exactly as described above.

During the course of the electrolysis different hydrates are present in the solution, from which they can be precipitated by taking out a sample and diluting it with an excess of water. In the early stages white $Pb(OH)_2$ is thus obtained. As time goes on the precipitate produced becomes more and more yellow, until finally precipitation starts in the electrolyte itself, without dilution.

The red lead obtained is free from metallic lead, but may contain some lead peroxide detached from the anode. It is in the form of a very fine powder, sometimes slightly crystalline, and varying in color from chocolate brown to bright red. The yield is better in the cold than at a higher temperature.

LEAD PEROXIDE.

It was stated above, in describing the method of preparing minium in the cold, that the current must be stopped as soon as oxygen is liberated. If the current is continued, the bath turns brown, and if now the electrodes and porous pot are taken out and the solution is boiled, anhydrous lead peroxide is precipitated. The process may also be modified somewhat, using a more dilute solution, as follows: Water, 500 parts; caustic potash, 100 parts; potassium nitrate, 25 parts. The anode is of lead sheet, the cathode an iron or lead plate. Current density at anode 0.4 ampere per square decimeter, at the cathode, any convenient value. The cathode is inclosed in a porous pot. Some ten ampere-hours are passed through the cell, and when oxygen begins to be liberated, the electrodes are taken out, and the solution is boiled. The anhydrous lead peroxide obtained is separated and washed by decantation, and finally upon a filter. The process may also be carried out at boiling heat, as in the preparation of red lead.

The product varies somewhat, from various shades of brown, to perfectly black. Possibly the black material contains higher oxides of lead.

As regards the technical application of the processes described, the principal obstacles would be the necessity of discontinuous working and the unavoidable slight loss of lead and caustic alkali. On the other hand, among the advantages gained is the elimination of danger of lead poisoning, to which the workmen are exposed in the processes at present in use.

* Abstracted from "La Préparation Electrolytique des Composés du Plomb," par Carl Duvivier. Malines, 1909. L. & A. Godenne.

In a paper presented to the Académie des Sciences, M. O. Bergstrand gives an account of a new method for determining the colors of stars by photography. Bergstrand uses for this purpose a method which was first employed by the Henry brothers of the Paris Observatory and then by M. Hertzsprung. The mean wave-length of the light from the star is photographically determined and thus a value found corresponding with the color. M. Bergstrand applies this method very successfully. He exposed plates in the large telescope of the Meudon Observatory. Before the opening is placed a grating composed of parallel bands of 1.5 millimeter (0.06 inch) spaced by an interval of the same length. This grating produces at the focus, besides the main image of the star, a series of diffraction spectra which lie symmetrically with relation to the image. Measuring the distance between two spectra of the first order, we find the effective wave-length for the star in question. He thus studied 92 stars, and finds that there are two general classes, the white stars, with wave length 420 $\mu\mu$, and the yellow stars of wave length 450 $\mu\mu$. These two classes are strongly marked.

ENGINEERING NOTES.

The manufacture of guncotton was commenced in 1863 at Waltham Abbey on a small scale under Abel's direction; it was not until 1872 that a factory capable of turning out about 250 tons of guncotton per annum was established there. The main portion of this factory consisted of old buildings which had formed part of the saltpeter refinery, and abutted on the principal street of the town. Fresh land, away from the town, was acquired in 1885, and a guncotton factory was built on it, and commenced work in 1890. It was considerably enlarged and altered in 1904-5, and is now capable of producing about 2,000 tons of guncotton per annum by the displacement dipping process of manufacture.

The value of naphthalene as a fuel for automobiles has been proved by the experiments of Chardon and Lion, with a 45-horse-power motor truck dragging another truck, the total useful load being 8 tons. The motor had four cylinders of 5.6 inches diameter and 6 inches stroke. The naphthalene was melted during the first 12 minutes run, in which gasoline was used as fuel. It was then introduced into the carbureter at a temperature of 80 deg. C. (176 deg. F.) together with air heated by the escaping gases. The escaping gases had no appreciable odor or color when the lubricant was not in excess. About 20 pounds of naphthalene were consumed per hour. The naphthalene was crystallized, in pieces the size of a chestnut, and contained less than ½ per cent of impurities. From observations made in the course of these trials, it appears that the naphthalene increases the effect of lubricants. Later experiments have given the cost of running at 1/3 to 2/3 cent per ton mile. The Gasmotorenfabrik Deutz uses naphthalene in briquettes. These are placed in a reservoir surrounded by pipes, through which flows water heated to the boiling point by the escaping gases. The carbureter is also heated. The start is made with gasoline, the use of which is continued until the water boils, usually about half an hour.

A new electrical device for sea sounding is used in Germany. The apparatus which are now employed for sounding and measurements of depth have a disadvantage lying in the fact that they must be brought to the surface after each measure of depth in order to make certain changes. For instance, the instrument which is now in use in the German navy consists of a glass tube which is silvered on the inside and is closed at the upper part. It is attached vertically to a heavy sounding lead. When the tube enters the water the latter penetrates more or less into the interior, compressing the air, and dissolves off the silvering of the tube. By measuring the height which is dissolved we have an estimate of the depth of immersion. The layer of silvering must be renewed at each measurement. In the electric device the tube is connected to a cylindrical portion containing mercury in such manner that when the air pressure inside the tube increases, the mercury is made to rise within the tube. A pair of high-resistance wires are mounted in the tube. With the mercury at the bottom, the resistance has a certain value, but when the mercury rises it surrounds the wires and the resistance is reduced according to the height of the mercury. The resistances can be measured on board the vessel by means of wires which run down to the tube, and we have a direct indication of the depth of the apparatus. Using a Wheatstone bridge to measure the resistances, the readings can be graduated directly in feet. Corrections are made for the barometric pressure and the variable density of the sea water.

SCIENCE NOTES.

Cyclamen seedlings normally have only one cotyledon. If this be entirely removed the second cotyledon will develop. If only the lamina be cut off, a new lamina will bud out from the side of the leaf stalk near the apex, and on the removal of this second lamina a third can be induced to grow out from its stalk just below the apex. If the lamina be mutilated and not wholly removed, new growths will also be formed.

The Veddas of Ceylon are now limited to the sparsely-settled country between the central hill *massif* and the eastern coast. A few still subsist on game, yams, and honey, and live in rock shelters, but the majority build huts and practise a little rude cultivation. Their ceremonial dances are essentially religious, and are performed to obtain the assistance of the spirits of their dead, who are called the Nae Yaku, or of certain long dead Vedda heroes, of whom the most important is the great Hunter, Kande Yaku, who is also Lord of the Dead. The dances are pantomimic, and are usually accompanied by an offering of food, around which the shaman dances as he invokes the *yaku*, by whom he is presently possessed. While in this condition, he prophesies the direction in which game will be found, and, at the end of the ceremony, the food to which the spirits have been called is eaten by the community.

Prof. James W. H. Trail, F.R.S., has made some preparations to illustrate the retention of colors, especially of green, in botanical specimens exposed to light. The specimens have been treated with acetate of copper, dissolved in acetic acid diluted with an equal volume of water. They are boiled in this solution as soon as possible after they are gathered, the aim being to form a copper-chlorophyl compound and to kill the protoplasm before decay begins. They are then washed thoroughly, and may be dried in the usual methods or mounted in fluids, such as spirit or 4 per cent formic aldehyde. The examples shown have been selected to show the application of the method to various groups of plants, from algæ to angiosperms. They show that the greens are varied after treatment, due to differences in the natural tints of the parts treated; that only those parts that contain chlorophyl are green in the preparations, and also that certain reds and other colors are frequently retained in these preparations. One or two treated without boiling in the copper solution are shown to illustrate the difference in results when similarly exposed to light.

In the Zeit. Instrumentech. K. Scheel and W. Heuse write on some experiments of theirs in the production of high vacua. The pressures obtained in a 6-liter vessel by several methods as follows were measured by means of the McLeod vacuum meter, graduated to 0.00005 millimeter. The highest vacuum obtained with the Toepler pump was about 0.000025 millimeter. With Zehnder's mercury pump a limiting pressure of about 0.001 millimeter was attained, as also found by Zehnder. A pressure of 0.00006 millimeter was attained in 45 minutes with a Gaede pump (new model), preceded by water pump, and of 0.00001 millimeter in 25 minutes when preceded by an oil pump. Reden's pump and Rosenthal's modification are practically double-acting Toepler pumps, and gave practically the same final pressure as Toepler's but in a shorter time. By use of charcoal cooled in liquid air a fall of pressure from 12 to 0.0012 millimeter was obtained in 48 minutes. With uncooled charcoal a fall from over 0.1 to 0.0013 millimeter in 32 minutes, and with the same charcoal in liquid air to 0.00026 millimeter in a further two hours was obtained. Proceeding in stages—water pump, Gaede pump, carbon, and liquid air—which are planned according to the size of apparatus to be evacuated, a vacuum of 0.00001 millimeter and even less can be attained with fair rapidity (40 minutes).

TRADE NOTES AND FORMULÆ.

Tectorium, a Substitute for Glass.—This material is prepared by applying a varnish to a finely-meshed iron-wire fabric. The varnish consists principally of good linseed oil, in which the vertically hanging wire fabric is repeatedly dipped up to as many as twelve times. After each dipping, the thin layer of oil is dried in warm air. The fabric thus obtained is exceedingly flexible, strong, impermeable, and very well adapted for skylights, greenhouses, etc.

Temperature Indicated by Paint.—According to Töllner, 100 parts each of iodide of mercury and iodide of copper are carefully rubbed down with sufficient distilled water to produce a spreadable paste. The color of this combination, at ordinary temperature, is red; at about 140 deg. F. it turns black but goes back to its red color on cooling. It is admirably adapted to show the heating of machine parts in inaccessible places.

Stamping Color for Linen.—10 parts each of pulverized dragon's blood gum and pulverized nitrate of silver are moistened through with a few drops of distilled water and the mixture increased by the addition of 10 parts of white dextrine and enough glycerine to give the mass the consistency of good printers' ink. The rubber stamps to be used should be rubbed off, before use, with a few drops of sweet almond oil. The color dries quickly and stands washing well. The color should be rubbed on pieces of velvet for transfering.

Terra cotta wood is made as follows: Mix, according to the degree of porosity it is desired to obtain, 1 to 2 parts of sawdust of highly resinous wood, with 1 part of washed kaolin and prepare from this, adding the necessary quantity of water, a plastic mass of spongy consistency, which is exposed, in metal cylinders, to heavy pressure by steel stamps. This produces cylindrical blocks of 8 to 12 inches diameter and 48 to 52 inches in length. They are first air-dried, then dried in a stove and finally placed in a kiln, where they are subjected to a white heat. The blocks, after cooling slowly, are said to be exceedingly durable and to be susceptible of sawing, cutting, planing, milling, and polishing. Their density is about one-half that of common brick. A special feature of the mass is its solidity. This wood is used with excellent results for building purposes.

Salicylic Paper.—Any kind of porous paper serves for its production and the quality is governed only by the purpose for which it is to be used. For honey, milk, cream, etc., white English filtering or blotting paper will serve; for butter, fresh meat, fruit, or vegetables, a paper not quite as soft is needed. It is, however, always better to use a paper that is not satinized. A sufficient quantity of salicylic acid is divided into two equal parts. One part is dissolved in a heated mixture of 3 parts glauber salts, 7 parts borax, and 58 parts water. The other half of the salicylic acid is, in the meantime, digested with some warm glycerine (specific gravity 1.1 or 1.15); one-third of the quantity of glycerine required for this purpose is gradually stirred in, then both mixtures are mixed together and water carefully added until a proportion of 3 per cent for thin and 5 per cent for the thicker paper is obtained. If the acid should crystallize, glycerine must be gradually added until the fluid is perfectly clear. Then the paper, one sheet at a time, is immersed in a large, shallow dish two-thirds filled with the fluid. If the solution has a temperature of 140 deg. to 150 deg. F., from 4 to 5 minutes will suffice; for thick paper a somewhat longer time will be required. If a cold solution is employed, each sheet must remain from 15 to 20 minutes in the bath, after which the papers are hung up in the sun, before the fire, or in an oven to dry. The paper must be kept in a dry, cool place, either pressed flat in a book or rolled up.

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